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Tumbler Ridge Cost-Effective Energy-Efficient New Housing

Research Report

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Canada

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TUMBLER RIDGE

COST-EFFECTIVE ENERGY-EFFICIENT NEW HOUSING

Prepared for
The Technical Research Division
Policy Development and Research Sector
of
Canada Mortgage and Housing Corporation

by

Saskatchewan Research Council

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EXECUTIVE SUMMARY

The main objective of this study was to find the most cost-effective energy conservation options for the residential units at the new mining town of Tumbler Ridge, B.C.

The options considered in the study were as follows:

- five residential types, including detached, semi-detached, row, apartment and pre-built.
- three different levels of energy conservation, with two or three options at each level.
- three different heating scenarios.

The incremental cost of construction, and the corresponding energy savings, have been determined for each combination of the above factors. The cost-effectiveness has been assessed in terms of present worth and in terms of reduced monthly payments on the part of the homeowners.

The findings show that the 'Measures' design is generally the most cost-effective when fuel costs are relatively low - such as might occur if district heating is adopted at Tumbler Ridge. The 'Retrofit-Ready' design is generally the most cost-effective when fuel costs are relatively high - such as would occur with electrical heating, or with natural gas at excessively high rates.

Affordability has been identified as an important factor at Tumbler Ridge. In this study, the sizes of the residential units have been reduced to an affordable level. It has been shown that the affordability can be jeopardised by the introduction of energy conservation measures, and that this problem can be overcome by adopting new procedures for assessing the qualifying income of the home owners. It has also been shown that the affordability rests on the assumed equality of construction costs at Tumbler Ridge and Dawson Creek. This will depend on the tendering policies and on the state of the housing market at the time of tendering.

It is shown that the analysis cannot be totally definitive, due to the several uncertainties currently existing. These include uncertainties about the residential heating system and its associated energy costs, uncertainties about the actual cost of construction at Tumbler Ridge, and deficiencies in the current state of the art for calculating residential space heating requirements.

Many municipalities have tax structures that penalize the adoption of energy conservation measures. At Tumbler Ridge an opportunity to exists to implement a tax structure that favours energy-efficient construction.

A technology transfer process has been recommended, based on the assumption that Tumbler Ridge will adopt either Measures or Retrofit-Ready designs. This process considers the requirements at three stages: during tendering, design and construction.

A five-year monitoring program has been recommended. The main objective of this program is to determine whether or not the Tumbler Ridge project has achieved its design objectives. The emphasis is therefore placed on simple, low-level analysis of fuel consumption, with supplementary technical monitoring on only a few houses.

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1. INTRODUCTION

Under the terms of a contract now being negotiated, British Columbia will supply metallurgical grade coal to Japan over a period of ten years, possibly extending to twenty five years or more. A new section of the B.C. coal resource will be developed to meet this demand, and a new, self-sufficient town will be built around the mining operation.

The new town will be named Tumbler Ridge. It will be located on the eastern edge of the Rockies, about 70 miles south-west of Dawson Creek, at a latitude of about 55 degrees. Preparatory work was started at the townsite in 1981. Residential construction will start in 1982 and will proceed through various phases to 1990, by which time it is planned to have 2390 residential units.

A great deal of thought is being given to the design of this township, which is hoped to serve as a model for future projects of this sort. The design effort includes two studies related to the energy aspects of the township: the first is a cogeneration/district heating study; the second is a study of the potential for energy-efficient housing, and is the concern of this report.

Three government agencies are involved in the energy aspects of the township design: the B.C. Ministry of Energy, Mines and Petroleum Resources, the Canada Mortgage and Housing Corporation, and the federal Department of Energy, Mines and Resources. This study has been conducted by Saskatchewan Research Council under contract to Canada Mortgage and Housing Corporation. The part of the study relating to building costs has been sub-contracted to Nu-Central Homes Ltd, of Saskatoon.

2. OBJECTIVES AND SCOPE

The objectives and scope of the study were as follows:

2.1 To review the various aspects of the Tumbler Ridge project and determine their probable influence on energy-efficient residential construction. This included a study of energy use options and their costs, prevailing building techniques and constructional factors, material availability, supply problems, state of preparedness of the local building industry, etc.

2.2 To evolve a range of conceptual designs, covering various levels of energy-efficiency, and to analyse the cost-effectiveness of each. Four different conceptual designs were evolved, ranging from standard construction up to Super Energy-Efficient (SEE). These were applied to the various housing types that will be used at Tumbler Ridge: detached, semi-detached, row, apartment and pre-built. Each combination of conceptual design and building type was analysed for cost-effectiveness under three scenarios of energy use. In each case the cost-effectiveness was determined by two different criteria: one related to the homeowner's monthly payments and one related to the present worth of the energy-conserving measure.

2.3 To propose methods and techniques for transferring the technology of energy-efficient construction to the builders and sub-trades involved in the project - during both the design and construction phases. The proposed methods and techniques take into account the probable levels of energy-efficiency, the builders' familiarity with the techniques, the mix of large and small builders, the inspection facilities available, local expertise, and the potential for creating expertise.

2.4 To propose a program for measuring and monitoring the performance of the residential units. This involves a consideration of the aims of the monitoring phase, and of the local resources available for this work.

Under the terms of the contract an interim report was to be submitted on completion of each of the above tasks. This final report, as required by the contract, is a compilation of the findings of all the tasks.

3. METHODS EMPLOYED

The study was started in August, 1981. Contact was made with the various principle agencies involved in the Tumbler Ridge project, to determine the strategies of energy supply, building population, financing, etc., and also to determine the involvement of the principle actors. A visit was made to Tumbler Ridge to evaluate site conditions and supply problems. The nearby centres of Chetwynd and Dawson Creek were also visited, and contact was made with local builders, suppliers and municipalities to identify prevailing building techniques, costs and local problems. This visit also revealed an interest in energy-efficient construction techniques at the Northern Lights Community College in Dawson Creek. The findings of this work were summarized in the first interim report, submitted in October 1981.

A preliminary analysis of the cost-effectiveness of energy-efficient housing was conducted in October. Four different levels of energy efficiency were considered: 1975 Standard construction, Measures, Retrofit-Ready and Super Energy-Efficient. Approximate levels of insulation and infiltration were developed for each, and the space heating requirements were calculated for representative designs of detached units, semi-detached, row, apartment and pre-built units, for each level of energy efficiency. This calculation used a simple equation developed by Saskatchewan Research Council. The incremental cost of the energy-efficient components was estimated on the basis of information supplied by a builder in Dawson Creek. The various figures were analyzed to determine the effect of the energy conservation measures on the monthly payments of the homeowners. An interim report was prepared, summarizing the results of the analysis. The main finding of this report was the identification of 'affordability' as a potential obstacle at Tumbler Ridge.

The two interim reports were submitted to a meeting of the principle agencies, held in Vancouver on November 5, 1981. This meeting was attended by representatives from the mining companies and the municipality of Tumbler Ridge. The meeting was particularly useful in bringing together, for the first time, the results of this study and the parallel study on co-generation. Following the meeting, Saskatchewan Research Council was asked to expand the cost-effectiveness analysis to include the sensitivity to various economic factors, and to provide data that would be needed for further analysis of the co-generation aspects.

The extended analysis was conducted through November and the early part of December, in close collaboration with CMHC staff. The analysis was refined in two successive stages: in the first stage the cost-effectiveness was extended to include the effects of fuel cost escalation and variations in incremental building costs. In the second stage the estimated energy savings were brought under closer scrutiny. These were calculated by the more accurate method built into the NRC HOTCAN program. At the same time, new information from the Saskatoon Energy Showcase project had indicated a possible discrepancy between actual and theoretical energy consumption. The discrepancy was large, and was taken into account when applying the results of the HOTCAN program. The results of this analysis were presented in the form of a revised second interim report.

Concurrently with this work, a preliminary report was prepared on the topic of technology transfer, inspection procedures and monitoring. This report was intended to be a comprehensive review of all the factors that might be taken into account, and was not specific to any particular strategy on energy conservation at Tumbler Ridge. This report, and the revised second report, were submitted to CMHC in December.

At this stage the study was brought to a temporary halt, pending further work on the co-generation study. CMHC was looking at the interactions between the two competing strategies of district heating and energy-efficient construction. The decisions, and the issues affecting them, were becoming more clearly defined. It was felt that, in the interests of making the best possible case for energy-efficient construction, the cost-effectiveness analysis should be conducted once more, using more definitive estimates of incremental building costs. Accordingly, Saskatchewan Research Council was given a contract extension, enabling the use of a professional cost estimator under sub-contract.

This stage of the work was initiated at the end of February, 1982, and was completed during the first three weeks in March. The sub-contractor prepared detailed estimates of the incremental costs of energy-efficient construction, embracing the four conceptual levels of energy conservation, detailed design variations and all building types. This information was used by SRC in a final analysis of cost-effectiveness. The results of this analysis were discussed at a meeting of CMHC, SRC and Nu Central Homes Ltd. (the cost-estimating sub-contractor). It was felt that the results were probably as definitive as could be obtained within the current state of the art, and SRC was instructed to incorporate this information in the final report.

4. FACTORS AFFECTING THE RESULTS OF THE STUDY

It is important to note that, during the course of this study, the technical base of the study has varied appreciably, and is still undefined even at this final stage. The following factors have a particular effect on the validity of the findings:

4.1 The strategy for residential space heating has varied throughout the study, and is still in a state of change. Natural gas space heating was the strongest option at the beginning of the study. It was demoted when it was discovered that the costs of running the pipeline to Tumbler Ridge would be far higher than originally supposed. At the same time, the co-generation study was beginning to show the economic advantages of district heating. This appears to be the strongest option at the time of preparing this report, though there is now a newly-emerging option in the form of a local natural gas drilling at Tumbler Ridge. Currently, therefore, the energy source and costs are uncertain.

4.2 The population of building types at Tumbler Ridge has been projected on the basis of experience at similar resource-based townships. This, however, does not take into account the current affordability crisis in the building market. If this situation persists, there might be a considerable shift towards cheaper housing types, such as row, apartment, or smaller detached and semi-detached units. An attempt has been made to accommodate this factor in the study, and there has been a steady progression to units of smaller floor area. Even so, at the present time, it is impossible to say what the floor areas will be in practice.

4.3 The details of house financing have varied at an unprecedented rate during the course of the study. A large number of innovative financing schemes have appeared on the housing market in the two-month period preceding this report. It would be difficult to evaluate the options without considerable analysis, and any selected mortgaging scheme is therefore subject to an element of doubt.

4.4 The methods for calculating the space heating needs of a house have been evolving rapidly over the last six months. The two most popular methods are the HOTCAN and the CMHC #2 computer programs. These have been changing rapidly, incorporating new technical factors according to the developing state of the art. At several instances throughout the study, both computer programs have been unavailable because of ongoing change and debugging. In such instances, the only alternative has been to use the less accurate earlier version of the HOTCAN program.

4.5 While the incremental cost of energy conservation measures can be estimated fairly accurately for Dawson Creek, it is virtually impossible to do the same for Tumbler Ridge. The costs at Tumbler Ridge will be determined by tendering policies, such as whether to encourage local builders, or whether to attempt minimal costs by encouraging large builders. The costs will also be determined by the state of the housing industry at the time of bidding. If the industry is still in the state of malaise that now exists, then the bids might be competitively low in the interests of securing work. On the other hand, if the situation of the industry improves (as it shows signs of doing), Tumbler Ridge might have to compete against the general backlog of building starts, and the costs might therefore be much higher than elsewhere.

In view of these factors, the results of this study cannot be considered to be definitive. They are restricted to a fairly judgemental range of situations. It is possible that this range will cover the actual situation at the start of construction, but there is a higher probability that it will not. If so, the results of this study will have to be extrapolated.

5. BACKGROUND INFORMATION

This is a review of the various factors affecting energy-efficient residential construction at Tumbler Ridge, and is a condensation of the information given in the first interim report.

5.1 Construction Schedule

Residential construction will proceed in several phases over the period 1982 to 1990. Site clearance and construction of access roads was started in 1981. The first two phases of residential construction will be completed in 1982, and will comprise about 1000 units, of various types. The status of units built in the first year appears to be uncertain; they may incorporate energy conservation techniques if the decision to do this is made in time. However, it looks as though zonal planning for optimum passive solar access will not be implemented until 1983.

Figure 1 shows the housing population, broken down according to building type, for the period 1982-90. For the purpose of analysis the single unit and duplex population has been arbitrarily split into small and large units, approximately equal in number. Otherwise, the data are as supplied by CMHC and give the projected population as planned at December 1981. Note that the pre-built units peak at 607 in 1985, and then reduce to 388 by 1990, reflecting the gradual reduction of site construction work.

5.2 Construction details

The predominant building form in the Dawson Creek area is platform-built wood frame on full concrete basement. Bi-level designs are popular, and pressure treated wood foundations are popular around Chetwynd. PWF foundations cost about 5% less than a comparable, uninsulated concrete foundation.

The majority of houses, of recent construction, conform to 1975 standards, with RSI 3.5 insulation in the ceiling, and RSI 2.1 in the walls. Concrete foundation walls are uninsulated.

One small builder in Dawson Creek, employing about 15 people, is specializing in energy-efficient construction and has built several houses to the standards of both 'Measures' and Super Energy-Efficiency (SEE). The incremental cost of the energy conservation features, according to this builder, are about 2.5% for Measures construction and about 7% for SEE construction - the percentages being related to the total house cost, inclusive of lot.

5.3 House Costs, Dawson Creek

Current house costs, as at March 1982, are $592 per square metre for bi-level designs and $560 per square metre for bungalow-with-basement designs. These figures apply to 1975 Standard construction in Dawson Creek and area, and do not include lot costs.

A serviced lot costs $20,000 in Chetwynd and $23,000 in Dawson Creek.

5.4 House Costs, Tumbler Ridge

One builder in Dawson Creek estimates that houses in Tumbler Ridge will cost $110 per square metre more than comparable units in Dawson Creek. He bases this on talk coming from the local contractors and sub-trades. SRC's consultant on cost estimating thinks that this is questionable; it will depend on what policy is adopted regarding the use of local builders or large builders at Tumbler Ridge. Large builders may actually be able to reduce the costs of construction at a remote building site, since they will tend to order supplies, and have them delivered, in bulk. The resulting cost reductions may offset the extra cost of relocating the building crews at a remote site. If the municipality of Tumbler Ridge adopts an open tendering policy, then the influx of large builders into Dawson Creek may cause a competitive reduction in the costs of construction at Tumbler Ridge. This will be especially true if the current state of the housing industry persists up to the time of bidding.

In December 1981 it was estimated that the cost of a serviced lot at Tumbler Ridge would be about $23,000. Some consideration was given to the possibility of subsidizing this down to $16,000, but this idea appears to have been abandoned in favour of a possible reduction in lot size. This issue has not yet been finalized.

5.5 Local Builders

The large builders have withdrawn from Dawson Creek, and the residual industry is made up of small companies, ranging from self-employed builders to slightly larger operations employing up to 15 people. The local sub-trade population appears to be adequate for local needs. The slump in building starts is not quite as bad as it was in late 1981, but it is not much improved. It can be assumed that local builders will be keen to get involved in the Tumbler Ridge project.

It is doubtful that the local builders, by themselves, could handle the 825 site-construction units planned for 1982. It is therefore likely that Tumbler Ridge will involve a mix of small local builders and large builders. This might introduce the advantages of competitive bidding as mentioned earlier.

5.6 Supply

The Anzac rail link is scheduled for completion in 1983. Until that time all supplies will be brought into Tumbler Ridge by road. Dawson Creek is the closest source of building supplies, but may not be able to handle the volume required. Prince George is a larger supply centre, and is currently used by several builders in Dawson Creek. It is possible that Dawson Creek and Prince George, in combination, could meet the supply needs of the project. Larger builders would probably make their own arrangements, which might not include these two centres.

5.7 Soil conditions

The soil at Tumbler Ridge consists mainly of sand and gravel, with occasional pockets of silt. The silt is potentially harm-

ful to basements. In Chetwynd, which has similar soil conditions, it is customary to remove silt pockets during construction, and to fill them with compacted gravel. The building regulations in Chetwynd do not call for any reinforcement of concrete foundations, though some builders do this on their own initiative.

It is interesting to note that PWF foundations are popular in Chetwynd. Because of the similarity of soil conditions at Chetwynd and Tumbler Ridge, it appears that PWF foundations would be potentially viable at Tumbler Ridge, subject to satisfactory treatment of silt pockets. Bi-level designs might also be appropriate.

5.8 The potential for solar usage

After the visit to Tumbler Ridge it was thought that the tree belts in the residential sector might shade the houses from direct solar access in winter, thereby preventing good passive solar design. It has since been learned that the majority of the tree cover will be removed to facilitate construction and provide fire breaks. There is, therefore, good potential for passive solar usage.

5.9 Pre-built units

These can be divided into two categories: the first covers temporary units, which will be removed on completion of the construction work; the second covers 388 permanent units that will be left in place after 1990. It is understood that the permanent units will have concrete basements.

There is good potential for energy conservation in pre-built units, but it is not certain how many of these will be suitable. Some units will be existing older designs, moved to Tumbler Ridge from another location. Others will be new units, built specifically for installation at Tumbler Ridge.

There is one sales outlet for pre-built units in Dawson Creek. This outlet handles three different designs, made in Penticton, Estevan and Red Deer. The Penticton manufacturer has been contacted. His design has RSI 2.1 in the walls, and RSI 3.5 in the floor and ceiling. This manufacturer would be most interested in manufacturing an energy-efficient design, including RSI 3.5 walls, airtight construction and improved window units. The cost of a standard unit, delivered to site, is $31,000 unfurnished and $36,000 furnished.

6. CLIMATE AT TUMBLER RIDGE

Dawson Creek, about 70 miles from Tumbler Ridge, is the closest centre with meteorological records. The climate is similar to that in the prairies, and the annual mean daily temperature variation is similar to that in Saskatoon. Figure 2 gives a comparison of mean monthly temperatures and monthly heating degree days for Dawson Creek and Saskatoon. This similarity is an important factor in the later analysis of residential space heating requirements. The HOTCAN program has a data base for Saskatoon but not for Dawson Creek, and therefore most of the computed performance data are based on Saskatoon conditions.

The annual heating degree day figure for Dawson Creek is 6152, and the total heating degree days over the period November to April inclusive is 4838. This differs by about 3% from the corresponding figure for Saskatoon.

The total annual precipitation at Dawson Creek is 424.7 mm, on long-term average.

7. FUEL COSTS AT TUMBLER RIDGE

The final decision has not yet been made regarding the method of residential space heating at Tumbler Ridge. At the start of this study, natural gas appeared to be the strongest contender, requiring the construction of a gas pipeline from Chetwynd to Tumbler Ridge. The cost of this pipeline has now been established, and is considerably higher than originally anticipated. Concurrently, the studies on district heating have shown that this might have economic advantages over the proposed natural gas system. At the moment, consideration is being given to the option of drilling for natural gas at the Tumbler Ridge site. The current situation is therefore as follows:

a) Natural gas still appears to be a strong option, but is dependent on various factors involved in setting up a local supply. Since this option has been introduced into the project only recently, the customer cost of the natural gas is uncertain. At its lowest, it may be on a par with the rates at Dawson Creek. At its highest, it may be closer to electrical rates.

b) District heating is also a strong option, using a co-generation system. The customer cost for space heating has not been determined precisely, though it could possibly be lower than the natural gas rate at Dawson Creek.

c) Electrical heating is not a strong option. If it were to be adopted, it would probably use an electrical grid supply brought into Tumbler Ridge. The rates would probably be close to the standard rates for B.C. Hydro.

At the start of this study, the first cost-effectiveness analyses were based on the assumption that residential space heating would be accomplished either by natural gas or electricity, at the normal rates of the utility. This assumption is no longer valid, but it is virtually impossible to replace it with any firm alternative. The object of this study is, in part, to analyse the cost-effectiveness of various energy conservation options using various energy cost scenarios. The type of heating is not important, provided that the scenarios cover a reasonably representative range of fuel costs. The standard B.C.

rates for natural gas and electricity give a fairly good range of fuel costs, and incorporate a scale of cost increases. Accordingly, the analysis will be based on these standard rates.

7.1 Natural Gas Costs

The 1981 rates, as obtained from the utility, are as follows:

First Gigajoule per month:	$4.57
Next 1.0 to 9.5 GJ per month:	$3.368 per GJ
Over 9.5 GJ per month:	$2.858 per GJ

It has been assumed that, over the period 1981 to 1987, the first rate will increase by 10% per year, the second rate by 15.5% per year and the third rate by 19% per year. From 1987 onwards the rates are assumed to increase by 12% per year. These figures are not exactly equivalent to those used by CMHC, but they produce averaged fuel costs that are very close to those produced by the CMHC formula.

Because of the three-rate structure the effective 'average' gas rate depends on the amount consumed each month. This is determined partly by the space heating consumption and partly by the domestic hot water heating consumption. Therefore, in calculating the effective rate for space heating, it is necessary to introduce a DHW base consumption effect. Figure 3 gives a cost analysis for five different levels of space heat consumption, ranging from 0 to 200 GJ per year. To simplify the analysis it is assumed that the space heat consumption is averaged over the 12-month period. The monthly gas consumption is then found to range from 2.8 GJ - the assumed DHW base - up 19.4 GJ. Figure 3 then shows the monthly gas bills as computed at 5-yearly intervals, using the above rates and increases.

From an analysis of these figures it can be shown that the effective rate, in 1982, is represented accurately by the formula:

$$\text{Effective 1982 rate (GJ)} = 3.4 + 0.89.\exp(-0.00527 \times \text{AGC}) \qquad 1.$$

-where AGC is the annual gas consumption for space heating only, in Gigajoules.

In a later section, the analysis will be extended to look at the 'present worth' of energy conservation measures. The present worth analysis is based on fuel savings over a 30-year period, starting in 1982, and assuming that all future savings are discounted by 14%, compounded annually. This complies with the assumptions used by CMHC in a parallel analysis.

The present worth of future fuel costs is given by:

$$\text{P.W.} = \text{1982 space heating bill} \times \text{multiplier} \qquad 2.$$

The multiplier varies slightly, according to the level of consumption, and is given by:

$$\text{Multiplier} = 0.0155 \times \text{AGC} + 25.35 \qquad 3.$$

-where AGC is once again the annual gas consumption for space heating.

7.2 Electrical Costs

The monthly rate for 1982 is taken to be:

$14.277 per GJ for the first 1.98 GJ
$9.610 per GJ for the remainder.

In a house that is totally heated by electricity, the annual consumption for electrical appliances and lighting is typically 21 GJ. The annual consumption for DHW heating is typically 16 GJ. The monthly base consumption is therefore about 3 GJ. It follows that any incremental consumption for space heat will fall in the range of the second electricity rate. Therefore, in an incremental analysis of space heat costs, it can be assumed that the second rate applies throughout. Following the parallel

study of CMHC, it will be assumed that the rate increases at 12% annually, compounded. Figure 4 gives the estimated electrical rates at 5-year intervals over a 30-year period.

The present worth multiplier, based on a period of 30 years with 12% escalation and 14% compounded discount rate, is:

$$P.W. = 23.48 \qquad 4.$$

8. BASE HOUSING COSTS

8.1 Typical Unit Size

In the earlier stages of this study, the cost-effectiveness analysis was based on the assumption that the residential units at Tumbler Ridge would have sizes typical of standard prairie construction. With this assumption, it was shown that the cost of standard units would create a general situation of 'unaffordability'. At the Vancouver meeting in November, the representatives of the mining companies commented that the assumed unit sizes were untypically high for mining townships. In response to this comment, and in an attempt to base the analysis on reasonably affordable units the following unit sizes have been assumed:

Large detached unit:	100 square metres plan
Small detached unit:	80.6
Large semi-detached:	96.0
Small semi-detached:	75.0
Row unit:	54.0
Apartment unit:	38.4
Pre-built:	91.0

All units except the apartment have two floors, and the living area is about twice the floor plan area shown above. The apartment unit has a total living area of 38.4 square metres, and is designed for single person accommodation. The detached and semi detached units are bungalows with full basement, and the row units are bi-levels.

8.2 Building Costs

The following are the latest data available for Dawson Creek:

Bungalow-with-basement:	\$560 per m^2
Bi-level, detached:	\$592
Bi-level, row :	\$370
Apartment:	\$310

The comparable costs for construction at Tumbler Ridge are uncertain. As indicated in Section 5.5, the incremental cost, in going from Dawson Creek to Tumbler Ridge, could be anywhere from 0% to 10%, depending on what is assumed about the tendering policy and the state of the housing market at that time.

The base cost of 1975 Standard housing has no effect on the cost-effectiveness of energy conservation measures, but it is essential to look at the base costs to see if an 'affordability' problem exists. For this affordability analysis, two scenarios will be assumed: the first with 0% increment over Dawson Creek, and the second with 20% increment.

8.3 Lot Costs

At the beginning of this study, the proposed lot cost was about $23,000. There is a possibility that this will be reduced by decreasing the lot size. A basic lot cost of $20,000 will be assumed for detached units. For other units the following lot costs are assumed:

Semi-detached	$17,000
Row	13,000
Apartment	8,000
Pre-built	17,000

8.4 Mortgage Costs

The house financing picture has changed considerably over the six-month period of this study. Originally, the most common mortgage system, based on NHA maximum loan ratios, was a multi-tiered system with different percentages of down-payment for different cost ranges. Currently, a large number of alternative schemes are being tried out by the various financing institutions. There has been a general tightening-up on equity requirements, and many instutions now require a minimum down-payment of 25%. Mortgage interest rates now range as low as 16.25%, but it is unlikely that such low rates will be sustainable in the long term. The deciding factor will be long-term investment interest

rates, such as the 17.5% that now applies to RRSP's. In view of this, many realtors expect the mortgage interest rate to stabilize at 18% over the short term.

For the purpose of the analysis in this study, the assumed mortgage system will be 25% down payment, with the remainder payable over 25 years at an interest of 18%.

8.5 Taxes

Property taxes are escalating rapidly, and it is difficult to preduct the starting tax levels for Tumbler Ridge. A tax of $1,500 will be assumed for a 100 square metre detached unit. The tax on other units will be pro-rated according to heated floor area.

8.6 Total Unit Costs

The above data, and assumptions, have been used to determine typical unit costs at Tumbler Ridge. These are summarised in figure 5. Some of the columns in this figure contain two costs; the upper is based on the assumption that Tumbler Ridge construction costs are identical to those at Dawson Creek, and the lower is based on the assumption that the Tumbler Ridge costs are 20% higher. The two figures are therefore a reasonable estimate of maximum and minimum costs.

8.7 The Affordability of Standard Housing

Figure 6 gives the estimated monthly P.I.T. payment and the corresponding qualifying income for the various types of units. These figures are based on the estimated unit costs given in figure 5, and include the two costing scenarios.

It is fairly clear that few of the families in Tumbler Ridge will have two incomes. The family income will therefore be

determined, in general, by the miner's income. The current wage rate appears to be in the range of $14 to $16 per hour. Assuming a 40-hour week, with no overtime, this works out to about $29,000 to $33,000 per year. Comparing these figures with the qualifying incomes in figure 6, it will be seen that the majority of the housing types are affordable - provided that the Tumbler Ridge construction costs are essentially the same as those at Dawson Creek. If, on the other hand, the Tumbler Ridge construction costs are 20% higher than at Dawson Creek (as anticipated by local builders), then affordability will become a problem, and the homeowners will be restricted to small semi-detached, row, apartment and pre-built units.

On the basis of this data, it can be said that the range of housing types and their related affordability will depend significantly on the construction cost difference between Tumbler Ridge and Dawson Creek. This has obvious implications for any policies regarding the choice of small local builders versus large builders.

Even with minimum construction costs at Tumbler Ridge, it will be seen that the detached and semi-detached units are marginally affordable. This applies to units built to 1975 Standards. Any increase in construction costs, due to the application of energy conservation measures, will tend to make some of the units unaffordable - if the affordability is based on the monthly P.I.T. payments. On the other hand, if the affordability criterion were to take into account the reduced monthly fuel bills, then many of the energy conservation options would remain affordable. This is something that might be negotiated with the financing institutions involved in the Tumbler Ridge project.

9. ENERGY CONSERVATION OPTIONS

The terms of reference of the study call for an analysis of energy conservation options in incremental cost steps of about $1,000. This presents a number of problems: the options rarely come in conveniently-sized increments, and a particular option may be inadvisable unless it is done in conjunction with another option. For example, it is inadvisable to attempt airtight construction without making allowance for ventilation and combustion air supply. It has therefore been decided to group the energy conservation options into a small number of packaged designs, covering the range from 1975 Standard construction up to very high levels of energy efficiency.

The selected options are as follows:

- 1975 Standard construction
- The NRC 'Measures' design (referred to as Measures)
- The Retrofit-Ready design (referred to as R-R)
- The Super Energy-Efficent design (referred to as SEE)

9.1 1975 Standard

This has been included to serve as a baseline for the incremental analysis.

Figure 7 shows the details of 1975 Standard construction for a platform-built bungalow with concrete basement. The features to note are:

- Ceiling insulation RSI 3.5
- Wall insulation RSI 2.1
- Foundation wall insulation zero
- Slab insulation zero
- Vapour barrier, standard 2-mil polyethylene construction.
- Roof trusses, standard hip.
- No air management
- No passive solar design.

9.2 Measures Options

The basic Measures design conforms to the requirements laid down in the 1980 NRC publication (1). This design will shortly be adopted as standard minimum construction in B.C. The details are shown in figure 8, for a platform-built unit with concrete basement. The features to note are:

- Ceiling insulation RSI 5.6
- Wall insulation RSI 3.5
- Foundation wall insulation RSI 1.4 over top 1200 mm.
- Slab insulation zero.
- Roof trusses have 57 mm heel.
- Wall is 38 x 140 studs x 600 mm on centres.
- Foundation stud frame is 38 x 38 x 600 mm on centres.
- Vapour barrier is standard 2-mil polyethylene, with some attention to sealing around doors and windows.
- No air management
- Passive solar design.

The above specifications comply with the Measures requirements, and are termed Measures #1 in the subsequent analysis. The analysis also considers two modifications of the Measures design:

Measures #2:

- The walls consist of 38 x 89 studs x 400 mm on centres. The insulation consists of RSI 2.1 batt in the stud frame, with RSI 1.3 Styrofoam SM sheathing, 38 mm thick. This option is shown in figure 9.

Measures #3:

- This is basically the same as Measures #1, except that the foundation wall insulation is carried to the footing.

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1. Measures For Energy Conservation in New Buildings, 1978, National Research Council, NRCC No. 16574

9.3 Retrofit-Ready

This design is the subject of a study conducted recently by Saskatchewan Research Council on behalf of CMHC, the aim being to evolve a target design for energy-efficient housing. The design is termed retrofit-ready because it concentrates on those aspects which will be difficult to retrofit at a later date. Other features, such as the ceiling insulation and the foundation insulation, are given less priority. The basic design is labelled retrofit-ready #1, and is shown in figure 10. The features to note are:

- Ceiling insulation RSI 7.1
- Wall insulation RSI 4.9
- Foundation wall insulation RSI 1.3, full height.
- Slab insulation zero.
- Roof trusses have 89 mm heel.
- Wall structure is 38 x 140 stud frame x 600 mm on centres, with vapour barrier, plus 38 x 64 horizontal strapping, on edge. Vapour barrier is buried in wall to protect against damage.
- Foundation wall insulation is 38 mm Styrofoam SM on exterior.
- Airtight vapour barrier construction, with 6-mil polyethylene.
- Simple air management system.
- Triple glazing on non-solar windows.
- 19 mm airspace double glazing on solar windows.
- Passive solar design.

Retrofit-Ready #2:

- This option is basically the same as R-R #1, except that the wall is sheathed with 38 mm Styrofoam SM to bring the total thermal resistance up to RSI 6.2. This avoids potential condensation problems due to thermal bridging of the studs. The details are shown in figure 11.

9.4 Super Energy-Efficient

This design is based on the 14 detached units in the Energy Showcase project in Saskatoon, 1980. The aim was to reduce the space heating consumption to 0.2 GJ per square metre of heated floor area. Details of this design are given in figure 12. The features to note are:

- Ceiling insulation RSI 10.6
- Wall insulation RSI 7.0
- Foundation wall insulation RSI 3.9
- Roof trusses are cantilever design.
- Wall structure is 38 x 89 outer frame, 600 mm on centres, with 38 x 89 inner frame x 600 mm on centres. Three layers of glass fibre batt.
- Foundation wall has 38 mm, RSI 1.3 Styrofoam SM on exterior and 38 x 89 stud frame on interior, set-back to allow two cross-lapped layers of insulation.
- Slab has 6-mil polyethylene moisture/vapour barrier and 25 mm Styrofoam SM insulation.
- Airtight vapour barrier construction.
- Air management system with heat exchanger.
- Windows are RSI 0.57 triple glazed throughout.
- Doors are thermal units.
- Passive solar design.

The above design is labelled SEE #1. The cost analysis has been conducted for a modification as follows:

SEE #2:

- Basically the same as SEE #1, but the slab insulation is increased to 50 mm Styrofoam SM (RSI 1.8).

9.5 Variations for Row Housing

The foregoing specifications apply mainly to bungalow designs with full concrete basement. In row housing it is common to use a bi-level design with a developed basement area. Figure 13 shows a six-unit configuration used for analysis in this study.

The detailed design variations for row housing are as follows:

1975 Standard:

- Details are shown in figure 14.
- The pony wall has the same specifications as the main wall.
- The foundation wall has RSI 2.1 insulation in a 38 x 89 stud frame.
- Other details are similar to bungalow-with-basement.

Measures:

- Details are shown in figure 15
- The pony wall has the same specifications as the main wall.
- The foundation design is identical with 1975 Std. above.
- All other details are identical to Measures #1.

Retrofit-Ready:

- Details are shown in figure 16.
- The pony wall has the same specification as the main wall.
- The foundation design has 38 mm Styrofoam SM on exterior, and 38 x 89 stud frame with RSI 3.5 insulation on interior.
- Other details are as given in Retrofit-Ready #1.

Super Energy-Efficient:

- Details are shown in figure 17
- The pony wall has the same thermal insulation as the main wall, but has a 38 x 140 bearing wall.
- The foundation wall has the same specification as the retrofit-ready design above.
- All other details are identical to SEE #1.

9.6 Variations for Apartment Design

The apartment design differs from the other types in having an unheated crawl-space foundation. Figure 18 shows a 12-unit walk-up configuration used for analysis in this study.

The detailed design variations are summarized in figure 19, and are as follows:

1975 Standard and Measures:

- Ceiling and wall details are as in corresponding bungalow designs.
- Floor is uninsulated.
- Vapour barrier terminates at base of exterior wall.
- Unheated crawl space with 38 mm rigid insulation on interior of grade beam.
- 6-mil polyethylene moisture barrier on base of crawl space.

Retrofit-Ready:

- Ceiling and wall details are as in bungalow retrofit-ready design.
- 6-mil polyethylene vapour barrier is carried around joist header and sealed to top of grade beam.
- 6-mil moisture barrier across base of crawl space acts as continuation of air-vapour barrier.
- Floor is uninsulated.
- Grade beam is insulated with 38 mm Styrofoam SM on exterior, carried over joist header.

Super Energy-Efficient:

- Ceiling and wall details are identical to corresponding bungalow design.
- Airtight vapour barrier construction is carried across floor.
- Floor is insulated with RSI 4.5 loose fill.
- Grade beam is insulated on exterior with 2 layers of 38 mm Styrofoam SM (RSI 2.7).
- Crawl space floor is fitted with 6-mil polyethylene moisture barrier and 38 mm rigid insulation to maintain crawl space temperature above freezing.

10. THE INCREMENTAL COST OF ENERGY CONSERVATION MEASURES

In the earlier stages of this study, the analysis of cost effectiveness was based on the estimates provided by a builder in Dawson Creek, as given in Section 5.2. Subsequently, these figures were felt to be on the optimistic side. Information from other projects indicated that the incremental costs might be considerably higher. A second analysis was therefore conducted, in which two incremental cost scenarios were used: the first scenario used costs approximately as given by the Dawson Creek builder, and the second scenario used costs that were 30% higher. While this showed the sensitivity to incremental cost assumptions, the range was felt to be too broad, and the figures were felt to be too undefinitive. Accordingly, SRC was asked to conduct a repeat analysis, with, as one of its objectives, an attempt to produce definitive estimates of incremental cost.

A sub-contract was given to Nu Central Homes Ltd., of Saskatoon, to conduct a detailed analysis of the incremental costs of the various energy conservation designs, as summarized in Section 9. The results are given in Appendix I. It is to be emphasized that these data sheets give builder costs, and use material and labour costs that are appropriate to Saskatoon.

The information in Appendix I has been summarized in Appendix II. These data sheets show the incremental cost of the various packaged options, and give the increment relative to three base designs: the 1975 Standard, Measures #1 and Retrofit-Ready #1. Here again, it must be emphasized that the data are builder costs appropriate to Saskatoon.

Nu Central estimates that these builder costs have to be increased by approximately 25% to 30% to give the actual customer cost in Tumbler Ridge. It has therefore been decided to increase the builder costs by 27.5%. This increase contains the following components:

- Builders overhead 10%
- Profit 7.5%
- Correction 10%

The correction of 10% represents the difference in construction costs between Saskatoon and Tumbler Ridge. In arriving at this figure, Nu Central have used the cost difference between Saskatoon and Dawson Creek, and have assumed that the Dawson Creek costs apply to Tumbler Ridge. In support of this assumption, Nu Central argue that bulk purchase and bulk transhipment will cancel out the additional costs of relocating the workforce at Tumbler Ridge. This, of course, assumes that large builders will play a major role in construction at Tumbler Ridge. Nu Central also argue that, if small local builders are also involved, the competition from large builders will bring the costs down - particularly if the local building industry continues to feel the effects of the current building slump.

Nu Central's arguments appear to be sound, and therefore the cost-effectiveness analysis has been based on their recommended increase of 27.5%. Nevertheless, there are still too many intangible factors in the Tumbler Ridge project for SRC to feel totally comfortable with this simple correction. It is the best available at the moment, but it may be necessary to apply an additional cost penalty when there is more information.

Figure 20 gives the estimated incremental costs for energy conservation measures at Tumbler Ridge. These costs include the factor of 27.5%, and the increments are expressed relative to 1975 Standard construction.

Figure 21 gives the corresponding increments on the down payment and the monthly P.I. payments. Figure 22 gives the corresponding present worth of the incremental costs. This present worth includes the down payment plus all the mortage incremental payments over the full 25-year term of the mortgage. The mortgage payments are discounted at 14%, compounded annually.

10.1 Incremental Taxes

In some municipalities the property taxes are related to the exterior dimensions of the house. In a house that has thicker walls, to accommodate the higher levels of insulation, the exterior dimensions are therefore greater for a given living area, and the homeowner effectively pays a higher tax per unit of living area.

This aspect has been explored with the Dawson Creek municipal authority. In this city the taxes are assessed on lot size, location and market value of the unit. As a matter of policy the assessed market value is assumed to be unaffected by any energy conservation measures, and therefore there is no direct tax on these measures. However, the assessed value is determined partly by the size of the unit (ie. its exterior dimensions) and there does not appear to be any compensation for the wall thickness penalty in an energy-efficient house. Therefore, although there is no direct tax on energy conservation measures, there may be an indirect one.

Many advocates of energy conservation have seized on this point, and have tried to promote changes in the tax structure to remove this indirect tax effect. The effect is difficult to quantify, because it depends so much on the rounding-off procedures that are applied to the exterior measurements. In Saskatoon, for instance, the city council has just issued a new directive concerning the measurement and rounding-off of house dimensions. This does not address the concerns about indirect taxation of energy conservation measures; in some cases it might work in favour of the measures, and in other cases against them, depending on the random nature of the rounding-off effect.

It is difficult to be precise about these tax effects without the benefit of a detailed study. Given that the Tumbler Ridge community is an exercise in energy-efficient design, it should be one of the objectives of this exercise to ensure that energy conservation measures are not penalized through the tax structure. Accordingly, in the following analysis, it is assumed that the appropriate tax structures will be applied at Tumbler Ridge, and the energy conservation options will involve no increase in taxes. Therefore, in the incremental analysis, the tax contribution will be ignored.

11. CALCULATION OF SPACE HEATING REQUIREMENTS

At the present time, the HOTCAN computer program and the CMHC #2 computer program represent the state of the art in estimating the space heating requirements of low-rise residences. Both programs are currently being upgraded and de-bugged, and neither was available for use in this study. Accordingly, the space heating requirements were calculated with the aid of an earlier version of HOTCAN, which lacks some of the refinements of the newest version. The main defects of this program are as follows:

- It has a fixed appliance and lighting gain of 17 kWh per day.
- It has no facility for introducing the biological heat generation of occupants.
- The climatic data base is limited, and the Saskatoon data fall closest to Tumbler Ridge conditions.
- The program cannot handle an unheated crawl space design, and therefore could not handle the apartment design.
- It has no facilities for dealing with a mixture of air infiltration and ventilation with heat recovery.

11.1 Correction for internal heat gains

The HOTCAN cases were run with the built-in heat gains. The computed space heating requirements were then corrected for proper internal heat gains using a theoretical expression developed by SRC during the course of the Saskatchewan Conservation House project. This expression is not too accurate when used on its own, but it is adequate for the corrections applied.

The following internal heat gain corrections were applied:

- For the detached units the electrical heat gain of 17 kWh per day was retained, and a biological heat gain of of 150 Watts was added.
- For the semi-detached units, which were run through the computer as one paired structure, the internal gains were increased to be consistent with two families, ie. 34 kWh per day electrical gain, and 300 Watts biological.

- The row units were run through the computer as three composit units, and the gains were increased to be consistent with occupancy by three families.
- For the apartment units, the total occupancy of a 12-unit apartment was assumed to give the same internal gains as three families (Note that these apartments are designed as batchelor or couple accommodation).

11.2 Correction to Tumbler Ridge Climate

The effect of climatic differences between Saskatoon and Tumbler Ridge was analysed at an earlier part of the study. It was found that the required correction was negligible for units built to 1975 Standard, Measures and Retrofit-Ready. For Super Energy-Efficient construction the correction was found to be about 0.95 - signifying that the computed space heat requirement has to be reduced by 5% for Tumbler Ridge conditions.

11.3 Dealing with Apartment Design

Since the program would not accept the apartment design, it was necessary to refer back to an earlier part of the study, in which the more recent version of HOTCAN had been used for analysis of apartment performance. The apartment configuration has changed significantly in the intervening period, and the computed space heat need was corrected to the new configuration using the theoretical expression described earlier. SRC is not too happy with the data resulting from this procedure, though it is the best that could be obtained, given the current problems of program availability.

11.4 Dealing with Infiltration/Ventilation

Though the program could not handle a combination of infiltration, ventilation and heat recovery, it was capable of handling a single infiltration value. Therefore, all air management data were entered as an infiltration. The assumptions were as follows:

- For 1975 Standard construction, the infiltration was assumed to be 0.6 air changes per hour, with no extra ventilation.
- For the Measures, the infiltration was assumed to be 0.5 ach.
- For Retrofit-Ready, the infiltration was assumed to be 0.3 ach.
- For Super Energy-Efficient, an infiltration rate of 0.1 ach was assumed, together with a ventilation rate of 0.2 ach and a heat recovery of 60% on the ventilation flow. This produced an effective infiltration rate of 0.18 ach.

11.5 Results of the Computation

The input data for the computations are summarized in the data sheets in Appendix III. These data sheets also show the heat loss coefficient of the unit shell, and the annual space heat requirement per unit, corrected for internal gain effects. The data therefore represent the best estimate of space heating requirements for Saskatoon conditions.

The annual space heat requirements, per unit, are summarized in figure 23, where they have been corrected to Tumbler Ridge climatic conditions.

11.6 Comments on the Validity of the Data

Two technical papers, issued recently in draft form, appear to cast doubts on the accuracy of computer predictions of residential space heating requirements. These papers (2,3)

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2. Besant, R.W. & Bengtson, S. Preliminary Computed Space Heating Performance Results for Fourteen Low Energy Passive Solar Houses In Saskatoon, Saskatchewan. Univ. of Sask., August 1981.
3. Dumont, R.S. Energy Consumption Measurements, Energy Showcase Project, Nov. 3, 1980 to Nov. 3, 1981. National Research Council Saskatoon, November 1981.

are based on the monitored performance of the 14 Super Energy-Efficient Houses in the Energy Showcase project in Saskatoon. Besant and Bengtson (2) note that the standard computer run underestimates the actual space heating requirements by a factor of two. It is understood that 'computer run' referred to is similar to HOTCAN. The figures given by Dumont (3) indicate a similar discrepancy between actual and theoretical performance.

The discrepancies are believed to be due to three main factors:

- Few of the houses were occupied over the full heating season during the monitored period, and the internal heat gains were therefore much lower than in normal occupation. The measured space heat consumptions were therefore unrepresentative.
- On inspection of the houses, several features were found to be operating below the rated performance. This applied particularly to ceiling insulation, mobile window insulation, heat exchangers and windows.
- The furnaces are operating significantly below their rated efficiencies.

The first factor explains a large part of the discrepancy. The second factor has a significant effect, but is a matter of quality control rather than a defect in the computer technique. The third factor is also significant, and is something that needs to be accommodated in the theoretical calculations. Dumont has noted that, when super energy-efficient houses are heated electrically, there tends to be good agreement between the theoretical and actual performance figures.

It can be concluded that computer programs such as HOTCAN are reasonably accurate,provided that the input data are an accurate description of the house and its components. Such accuracy may not be possible when specifying the seasonal efficiency of the furnace system, particularly with the new kinds of installations that are being tried

in energy-efficient housing. The performance of furnaces in energy-efficient structures still requires further investigation. In the meantime, Dumont's comment (on page 35) suggests that the rated furnace efficiency is not an accurate representation of the furnace performance, even in cases where it might appear to be so.

In the following analysis, and based on the above remarks, it will be assumed that the 'standard' furnace has a seasonal efficiency of 60%, and the second generation furnace has a seasonal efficiency of 70%.

12. COST-EFFECTIVENESS ANALYSIS

This has been conducted for three heating situations:

- Natural gas heating, with 60% furnace efficiency.
- Natural gas heating, with 70% furnace efficiency.
- Electrical heating, assumed 100% efficient.

12.1 Natural gas, 60% efficiency

Figure 24 gives the average monthly fuel bills (for space heating) for the various building configurations. The data are based on the annual space heat requirements given in figure 23, and include the effect of a 60% furnace efficiency. Note that all configurations are assumed to have the same kind of furnace.

Figure 25 gives the savings on monthly fuel bills, using a 1975 Standard unit as the base.

Figure 26 combines the monthly savings, from figure 25, and the incremental monthly P.I.T. payments from figure 21. This gives the actual increment that the homeowner will experience in his combined monthly heating bills and P.I.T. payment. A negative value indicates a reduced monthly bill, and a positive value indicates an increased monthly bill. If these figures are used as a basis for cost-effectiveness, then they obviously favour a Measures type of construction.

The cost-effectiveness can also be assessed in terms of present worth. Figure 27 gives the present worth of fuel savings over a 30-year period, using the calculation procedures described in Section 7. The true present worth of the energy conservation measures is determined by subtracting the present worth of incremental construction costs from the present worth of fuel savings. This is done in figure 28, using the data from figures 22 and 27.

The present worth takes into account the future escalation of fuel costs, and might therefore be expected to favour higher levels of energy conservation. Figure 28 shows that the Retrofit-Ready options have the highest present worth, with the Super Energy-Efficient designs following closely. The row and apartment units, which are intrinsically energy-efficient, do not conform to this trend. For these units, something between the Measures and Retrofit-Ready designs would be optimum.

It is informative to compare the Measures #1 and Measures #3 designs. The two are very similar, but in the Measures #3 design the foundation wall insulation is extended down to the footing. Figures 26 and 28 show that this is a marginally cost effective option. However, it should be borne in mind that the HOTCAN program is particularly weak in allowing for soil insulation effects around foundation walls. Consequently, the distinction between Measures #1 and Measures #3 cannot be regarded as being definitive.

12.2 Natural gas, 70% efficiency

The analysis and presentation of data is similar to that of the preceding section. The results are given in figures 29 to 33. It is assumed that all building configurations are heated with a 70%-efficient furnace.

Figure 31 gives the monthly P.I.T.H. increment, and figure 33 gives the combined present worth of the energy conservation measures. This scenario, with a 70% furnace efficiency, tends to favour slightly lower levels of energy-efficiency - as compared with the previous case. This is to be expected, since the cost of delivered heat is slightly lower. Using monthly P.I.T.H. increments as the basis for cost-effectiveness, the Measures once again emerges as the optimum. Using present worth as a basis, the Retrofit-Ready designs are once again the optimum. The row and apartment units again break away from the general trend, favouring measures construction on the basis of monthly payments, and something between Measures and Retrofit-Ready on the basis of present worth. Measures #3 continues to show a marginal improvement over Measure #1.

12.3 Electrical heating

The analysis and presentation of data is similar to that of the two preceding sections. The results are given in figures 34 to 38.

Figure 36 gives the monthly P.I.T.H. increments, and figure 38 gives the combined present worth. The higher cost of electrical heating tends to shift the optimums towards the higher levels of energy efficiency. The Retrofit-Ready designs emerge as the optimum on the basis of monthly payments. On the basis of present worth there is not much to choose between the Retrofit-Ready and the Super Energy-Efficient designs.

A critical situation arises in row and apartment units with electrical heating. The choice of the most cost-effective option depends critically on the basis for defining cost-effectiveness. If monthly payments are used as a basis, then the Measures is optimum. If present worth is used as a basis, then Retrofit-Ready is optimum.

Measures #3 continues to show a marginal improvement over Measures #1.

12.4 Cost effectiveness of furnace options

Two types of gas furnace, with 60% and 70% efficiencies, have been studied in Sections 12.1 and 12.2. However, the effect of these furnaces was not considered in isolation; fuel bills were analysed for different building configurations with the same type of furnace. This Section therefore looks at the cost-effectiveness of one furnace type relative to the other.

The following assumptions are made:

- The 70%-efficient furnace has an incremental cost of $350, relative to a 60%-efficient furnace.

- The furnace will have a lifetime of 20 years.
- Maintenance costs of the two furnaces are identical.

Using calculation methods developed earlier in this report, it follows that:

- The increment on the down payment is about $87.
- The increment on monthly P.I.T. payment is $3.86.
- The shift from a 60% to a 70% furnace reduces fuel consumption by 23.8%.

With further analysis, it can be shown that:

- The shift from a 60% to 70% furnace will give a decrease in monthly P.I.T.H. payments if the annual space heating requirement of the residence is 49 GJ or greater.
- The shift from a 60% to a 70% furnace will show an increase in present worth if the annual space heating requirement of the residence is 18 GJ or greater.

Figure 39 shows which types of building configuration favour the 70%-efficient furnace, using each of the above criteria.

13. TECHNICAL CONCLUSIONS AND RECOMMENDATIONS

It would not be appropriate to discuss the technology transfer needs at Tumbler Ridge without first having some clear idea of the technical objectives. It is therefore considered advisable to discuss the technical conclusions and recommendations at this stage of the report.

13.1 The cost-effectiveness of a range of energy conservation meas- has been analysed on the basis of present worth and the effect on monthly P.I.T.H. payments. This analysis has been repeated for three different modes of heating. Generally, the Measures and Retrofit-Ready designs display the highest cost-effectiveness across the whole range of the analysis. Super Energy-Efficient designs become competitively cost-effective when the heating mode involves high fuel cost - as in electric heating - but generally the SEE design is less cost-effective than other design options.

13.2 In the analysis, the heating mode with the lowest fuel cost was natural gas with a 70% furnace efficiency. In this heating mode, the Measures design was generally the most cost-effective in terms of monthly P.I.T.H. payments, but the Retrofit-Ready design was most cost-effective in terms of present worth. If district heating is adopted at Tumbler Ridge, there is a possibility that the heating cost (to the consumer) will be lower than with natural gas and 70% furnace efficiency. In this event, the Measures design will emerge more strongly as the most cost-effective option.

13.3 In the analysis, the heating mode with the highest fuel cost was electrical heating. In this heating mode, the Measures and Retrofit-Ready designs were generally the most cost-effective options in terms of monthly P.I.T.H. payments - with not much to choose between them. The Retrofit-Ready and Super Energy-Efficient designs were the most cost-effective in terms of present worth. If Tumbler Ridge were to adopt a heating mode with a fuel cost higher than that of electricity, the Retrofit-Ready design would probably constitute the most cost-effective option.

13.4 On the basis of the previous conclusions, it is recommended that attention be focussed on the Measures and Retrofit-Ready designs at Tumbler Ridge.

13.5 If district heating is adopted at Tumbler Ridge, and if it proves to have a lower consumer cost than the natural gas options considered in this study, the Measures should be adopted as the basic standard of construction. However, if a district heating system is used, the houses will have no combustion units and there will be a risk of humidity build-up and moisture penetration into the building envelope. Therefore, where district heating and Measures construction are used in combination, the Measures design must be modified to include an airtight vapour barrier construction and a simple air management system. This will have only a small effect on the cost-effectiveness of the design.

13.6 If Tumbler Ridge adopts an electrical heating system, or a natural gas system with comparable fuel costs, the Retrofit-Ready design should be adopted as the basic standard of construction.

13.7 If the Measures design is adopted at Tumbler Ridge, it should include a full-height foundation wall insulation, as detailed in this report under the Measures #3 design. This option appears to be marginally cost-effective over the full range of conditions included in the analysis.

13.8 If the Retrofit-Ready design is adopted at Tumbler Ridge, it should conform to the design labelled Retrofit-Ready #2 in this report. This design is marginally less cost-effective than the Retrofit-Ready #1 design. However, the #2 provides a safeguard against the possibility of a dewpoint condition within the wall structure.

13.9 If natural gas is used for space heating at Tumbler Ridge, it will be generally more cost-effective to use the 'second generation' furnace designs, with rated efficiencies around 80%. Apartments are the exception to this rule: a standard furnace, rated at about 75% efficiency, is the best option for apartments - given the natural gas costs assumed in this report.

13.10 For maximum cost-effectiveness, apartments and row units generally require lower levels of energy conservation than detached or semi-detached units. However, the cost-effectiveness will not be altered much if the apartments and row units are built to the same standards as the rest of the residential stock. Since this would simplify the technology transfer process and the builders' operations, it is recommended that the same standard of construction be applied across all building types.

14. THE TECHNOLOGY TRANSFER PROCESS

14.1 Objectives

The main objective of the technology transfer process is to ensure that the conceptual designs are translated into competent residential units, operating at the required levels of energy efficiency and cost-effectiveness. This involves technology transfer at three main junctures:

- during the tendering stage,
- during the design stage,
- during the construction stage.

Also, the effectiveness of the Tumbler Ridge project can be significantly increased by exploiting the training opportunities that it offers. There is a rapidly growing need for energy conservation expertise in all sectors of the building industry. With proper planning, Tumbler Ridge can help to provide this expertise.

14.2 Review of factors

It is assumed that about 1,000 residential units will be built at Tumbler Ridge in the first year, and about 500 units, or less, in each subsequent year. These units will embrace the various residential types considered in this study.

The level of energy-efficiency has not been determined, but it is assumed that the construction details will conform to either the Measures or Retrofit-Ready designs.

The details of the technology transfer process will be partly determined by the builders involved in the project. It is assumed that small and large builders will be involved, and that their previous experience in energy-efficient construction will vary considerably from one builder to another. The same goes for the designers.

In addition to the normal house inspection requirements, separate inspections will be required for some of the energy conservation aspects of the construction. These inspection requirements will be most critical in the first year of construction, for three reasons:

- The greatest rate of building starts will occur in the first year.
- The inspectors will be learning how to deal with the new requirements in the first year.
- Stringent inspections will be needed at first, to ensure that builders and trades make an effective and rapid transition to the new constructional techniques.

The inspection requirements will decline considerably in subsequent years, and something like a 20% spot inspection may be adequate.

Assuming that each unit will involve at least half a man-day of inspection effort in 1982, and assuming that 1,000 units will be completed within a building season of 150 days, it follows that at least three inspectors will be required in the first year. If one man-day is allowed for each unit, which seems to be a more advisable level of inspection in the first year, then six inspectors will be needed.

The municipal authorities at Tumbler Ridge are in the process of hiring inspectors. It is planned to have a Chief Inspector in office by the end of April, with four building inspectors to be hired as work progresses. It is assumed that only a small part of their effort will be dedicated to the energy efficient aspects of construction. Therefore, it may be necessary to augment this inspection staff in the first year.

This creates an opportunity to train CMHC inspectors in energy conservation construction. There would be some advantage in seconding two senior CMHC inspectors to Tumbler Ridge during the first year of construction. The experience they gain in this project can then be disseminated to other inspectors in CMHC.

The Northern Lights Community College, in Dawson Creek, has a declared interest in energy-efficient construction. This College would like to be involved in the Tumbler Ridge project. This involvement could take two forms:

- The College could be allowed to use the Tumbler Ridge project as a training resource for its students.
- The College could provide a service to the project, in some technical capacity. Such services might include special testing or monitoring.

In deciding how to interface with the builders, it is useful to consider the experiences of Saskatchewan's Home Energy Loan Program. This program gives a $3,000 no-interest loan to home owners who are prepared to build a new house to a certain level of energy efficiency. This level, and the constructional details, are in many respects similar to the Retrofit-Ready design covered in this study. Airtightness tests have been conducted on 18 houses built to H.E.L.P. standards. Some of the houses were built by trades who had had no previous experience of energy-efficient construction. Their only guide was a prescriptive construction standard. Even so, the airtightness performance of these houses came remarkably close to the values measured on the 14 houses in the Energy Showcase. In fact, in some cases, the H.E.L.P. houses were more airtight than some of the Energy Showcase houses - which were built under fairly stringent inspection procedures.

The airtight construction details comprise the biggest and most important difference between standard and energy-efficient construction. Up to now, it has been assumed that good levels of airtightness could only be achieved through intensive instruction and quality control. The experiences of the H.E.L.P. program show that this is not so; adequate standards of airtightness can be achieved with fairly minimal levels of instruction and inspection, provided that the builder is given the right sort of information.

14.3 Recommended procedures, tendering stage

The published Call for Tenders should identify the importance of energy-efficient construction in this project. This will help to attract builders who have a degree of commitment to improved constructional standards.

Applicants should be required to attend a pre-tender workshop, lasting for not more than half a day. The purpose of this workshop will be to acquaint the builders with the technical requirements. An information kit, including typical design details, should be given to each applicant. The workshop should allow for an extended question-and-answer session, and will give the builders the information they need to prepare realistic cost estimates.

Funding should be made available to cover the costs of preparing the informational material and running the workshop. The venture should be organised and designed by a small group, consisting of energy conservation consultants and representatives of the agencies involved in the project.

14.4 Recommended procedures, design stage

A small Design Review Group should be established for this stage, and funding should be made available to cover the cost of operation of the group.

The first activity of the group will be to provide a general design guideline. It is suggested that this guideline be based on prescriptive constructional details rather than on prescriptive performance requirements. However, the prescriptive details should be presented in a way that allows the designers a reasonable level of flexibility. Designers should be encouraged to develop their own design variations, but they should also be required to demonstrate that these variations will result in an appropriate level of energy-efficiency. Computer design assistance should be made available to those designers who require it.

Designers should be given the option of submitting their final designs to the review group for comment, but should not be formally required to do so. In the first year of construction there may be as many as 50 to 100 different designs, and it would be very time-consuming to conduct a detailed examination of all of them (it is assumed that the contract documents will require the designs to conform to a certain set of standards). However, it would be advisable to have designers acquaint the Review Group with any usual design features, so that these can be incorporated in the subsequent workshops for the construction phase.

14.5 Recommended procedures, construction phase

A one-day workshop should be held prior to the start of construction. This should be attended by builders, sub-trade foremen and inspectors. A few representatives from the Northern Lights Community College should also be encouraged to attend. In fact, it might be appropriate to hold the workshop at that College. The aim of this workshop will be to acquaint the attendees with the non-standard features and requirements of energy-efficient construction. Any unique features, developed by the various designers, will be included.

A schedule of special inspection requirements should be drawn up for the inspectors. This is expected to concentrate on at least three factors:

- Exterior foundation insulation
- Wall and ceiling insulation
- Vapour barrier construction and sealing.

The Tumbler Ridge municipal building inspectors should be encouraged to take a leading role in this aspect of inspection. Also, two senior inspectors from CMHC should be encouraged to take part.

It is recommended that the Northern Lights Community College be given funding to purchase an airtightness testing system, and acquire expertise in its use. In return, the College should be required to conduct airtightness tests on at least 40% of the units built at Tumbler Ridge. If the details of this arrangement are worked out properly, it will result in considerable benefits to both the Tumbler Ridge project and the College.

From 1983 onwards, inspection and airtightness testing can be conducted on a random spot-check basis, under the total responsibility of the municipal building inspectorate.

15. RECOMMENDED MONITORING PROGRAM

15.1 Objectives

As its main objective, the monitoring program should show how suceesful the Tumbler Ridge project has been in meeting the design energy conservation target. This can be accomplished by monitoring the energy consumption of the individual units.

As a secondary objective, some houses should be subjected to a more detailed monitoring study, aimed at defining some of the more important aspects of energy performance.

15.2 Structure of the program

It is recommended that the monitoring program cover a period of 5 years, and be co-ordinated by a contracted consultant. This consultant will be required to analyse data at yearly intervals, and present a yearly report. On completion of the monitoring work, all findings should be compiled into a final report. The consultant will also be required to administer the routine data gathering operations.

Routine data gathering can be achieved in one of three ways:

- Under sub-contract to Northern Lights Community College.
- By using local housewives, who may welcome this opportunity to earn pin money.
- By extending the meter-reading operations of the power utility.

Airtightness tests should be conducted by Northern Lights Community College, under contract.

It is recommended that all fuel and energy meters be located on the exterior of the residential units, to facilitate monitoring.

15.3 Recommended monitoring

The energy consumption of all units should be recorded either at monthly intervals or at two-weekly intervals - preferably the latter. The monitoring records should show the level of occupancy and the type of unit.

Extra metering facilities should be installed in 30 to 40 houses to allow the separation of energy consumption by space heating and DHW heating. These houses should be monitored on the same schedule as above.

Home owners should be polled yearly, to see if they have experienced any operational problems, such as poor air quality, condensation or structural deterioration.

Ten houses should be selected for periodic airtightness testing, to provide information on the long-term behaviour of energy-efficient construction. The houses should be given an airtightness test every year for five years.

Thirty to forty houses should be given an airtightness test at the end of the monitoring program, to supplement the information from the above tests. These tests should also include an inspection of the condition of the vapour barrier and the insulation in the attic.

Climatic data can be monitored in one of two ways: either by using the existing meteorological facilities at Dawson Creek, or by setting up a small station at Tumbler Ridge, with assistance from Atmospheric Environment Services.

Five houses, at most, should be equipped with extra instrumentation and data logging facilities, with the aim of measuring selected aspects of house behaviour, such as soil temperature effects or moisture content in walls.

16. NON-TECHNICAL CONCLUSIONS AND RECOMMENDATIONS

16.1 Affordability is an important factor at Tumbler Ridge. It is based on qualifying income, which in turn is based on monthly P.I.T. payments. An attempt has been made, in this study, to bring the residential units into the range of affordability by reducing their sizes. With the sizes selected in this study, most of the residential options are affordable, if built to 1975 Standard construction.

16.3 In the technical conclusions and recommendations (Section 13), the Measures and Retrofit-Ready designs were shown to be the most cost-effective options in a particular set of circumstances. Generally, these designs will decrease the total monthly payments of the homeowner. The procedure for assessing qualifying income has to be changed to accommodate this factor. Currently, the assessment takes into account the increase in capital cost of the unit, but does not allow for the corresponding decrease in fuel bills. Therefore it tends to militate against energy conservation options. It is particularly important to change this procedure at Tumbler Ridge, since the 1975 Standard units are marginally affordable , and any increase in capital cost will threaten the affordability.

16.4 It has been shown that most of the housing options at Tumbler Ridge will be marginally affordable, on the basis of monthly P.I.T.H. payments. This assumes that the construction costs at Tumbler Ridge will not be significantly greater than those at Dawson Creek. There is some justification for this assumption, though it will depend on the state of the housing market and on the tendering policies adopted at Tumbler Ridge. Given competitive tendering, and the existing slump in the housing market, the construction costs may prove to be similar to those at Dawson Creek.

16.5 Many municipalities have property tax structures that penalize energy-efficient construction, either directly or indirectly. At Tumbler Ridge there is an opportunity to start off on the right foor, by evolving tax structures that will encourage energy conservation.

			UNITS					
YEAR	LARGE SINGLE	SMALL SINGLE	LARGE DUPLEX	SMALL DUPLEX	ROW	APART.	PRE-BUILT	TOTAL UNITS
1982	146	146	25	25	65	440	164	1011
1983	272	272	44	45	110	740	292	1775
1984	366	367	57	59	110	740	556	2225
1985	408	409	62	63	110	740	607	2398
1986	433	434	63	65	110	740	591	2436
1987	445	446	63	65	110	740	517	2386
1988	465	466	64	66	110	740	474	2385
1989	486	488	65	68	110	740	431	2388
1990	507	510	65	70	110	740	388	2390

FIG. 1 SUMMARY OF HOUSING TYPES AT TUMBLER RIDGE FOR PERIOD 1982-1990.

	Celsius Degree Days		Mean Monthly Temp.(°C)	
	Dawson Cr.	Saskatoon	Dawson Cr.	Saskatoon
January	1077	1122	-17.8	-18.7
February	851	929	-12.5	-15.1
March	769	821	-7.2	-8.7
April	459	440	2.4	3.3
May	271	225	9.1	10.6
June	151	94	13.3	15.4
July	93	28	15.3	18.8
August	122	52	14.1	17.4
September	251	190	9.9	11.3
October	426	383	4.3	5.0
November	727	699	-6.3	-5.8
December	955	982	-13.9	-14.0
For the year:	6152	5965	0.9	1.6
For November-April inclusive:	4838	4993		
Total annual precipitation:	Dawson Creek	424.7 mm		
	Saskatoon	344.8 mm		

FIG. 2 CLIMATIC DATA

ANNUAL SPACE HEAT CONSUMPTION (GJ)	200	150	100	50	0
AVERAGE MONTHLY CONSUMPTION FOR SPACE HEAT & DHW	194	15.3	11.1	6.0	2.8
		MONTHLY GAS BILL (AVERAGE)			
1982	$ 72	$ 58	$ 44	$ 28	$ 12
1987	157	124	90	56	23
1992	277	219	159	99	41
1997	488	385	280	174	71
2002	859	679	493	307	126
2007	1514	1196	868	540	222
2012	2669	2108	1530	952	391
		AVERAGE GAS RATE $/GJ			
1982	3.71	3.79	3.96	4.06	4.29
1987	8.09	8.11	8.11	8.12	8.21
1992	14.28	14.31	14.32	14.35	14.64
1997	25.15	25.16	25.23	25.22	25.36
2002	44.28	44.38	44.41	44.49	45.00
2007	78.04	78.17	78.20	78.26	79.29
2012	137.57	137.78	137.84	137.97	139.64

FIG. 3 GAS COST ANALYSIS.

1982	$9.610 per GJ
1987	16.94
1992	29.85
1997	52.60
2002	92.70
2007	163.37
2012	287.92

FIG. 4 ELECTRICAL RATES OVER 30 YEARS

	(1) HEATED FLOOR AREA m^2	BUILDING COST PER UNIT	LOT COST PER UNIT	TOTAL COST PER UNIT
100 m^2 DETACHED	200	56,000 67,000	20,000	76,000 87,000
80.6 m^2 DETACHED	161	45,000 54,000	20,000	65,000 74,000
96 m^2 SEMI-DETACHED	192	48,000 58,000	17,000	65,000 75,000
75 m^2 SEMI-DETACHED	150	38,000 45,000	17,000	55,000 62,000
54 m^2 ROW	108	20,000 24,000	13,000	33,000 37,000
38.4 m^2 APARTMENT	38	12,000 14,000	8,000	20,000 22,000
91 m^2 PRE-BUILT	182	36,000 38,000	17,000	53,000 55,000

Note: (1) Includes areas of heated basement

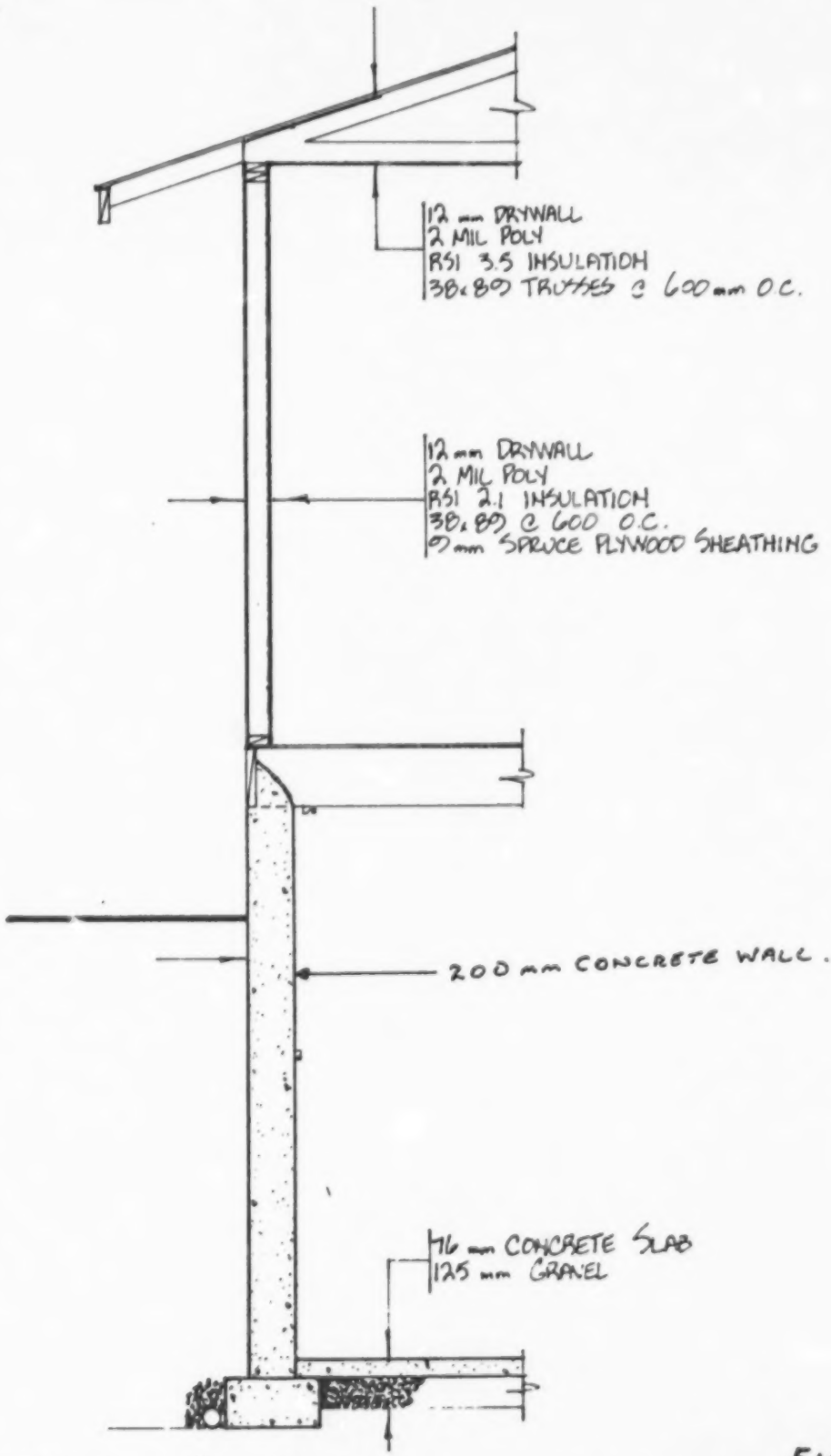
* UPPER FIGURES ARE DAWSON CREEK + 0%
* LOWER FIGURES ARE DAWSON CREEK + 20% (rounded to nearest $1,000)

FIG. 5 ESTIMATED COSTS, 1975 STANDARD RESIDENTIAL UNITS AT TUMBLER RIDGE.

	UNIT COST	DEPOSIT	MORT	MONTHLY P.I.	ANN. TAX.	MONTHLY P.I.T.	QUALIF. INCOME
100 m^2 DETACHED	76,000 87,000	19,000 21,750	57,000 65,250	836 957	1,500	961 1082	38,400 43,200
80.6 m^2 DETACHED	65,000 74,000	16,250 18,500	48,750 55,500	715 814	1,200	815 914	32,600 36,500
96 m^2 SEMI-DETACHED	65,000 75,000	16,250 18,750	48,750 56,250	715 825	1,440	835 945	33,400 37,800
75 m^2 SEMI-DETACHED	55,000 62,000	13,750 15,500	41,250 46,500	605 682	1,120	698 775	27,900 31,000
54 m^2 ROW	33,000 37,000	8,250 9,250	24,750 27,750	363 407	810	430 474	17,200 18,900
38.4 m^2 APARTMENT	20,000 22,000	5,000 5,500	15,000 16,500	220 242	290	244 266	9,800 10,600
91 m^2 PRE-BUILT	53,000 55,000	13,250 13,750	39,750 41,250	583 605	1,365	697 719	27,900 28,700

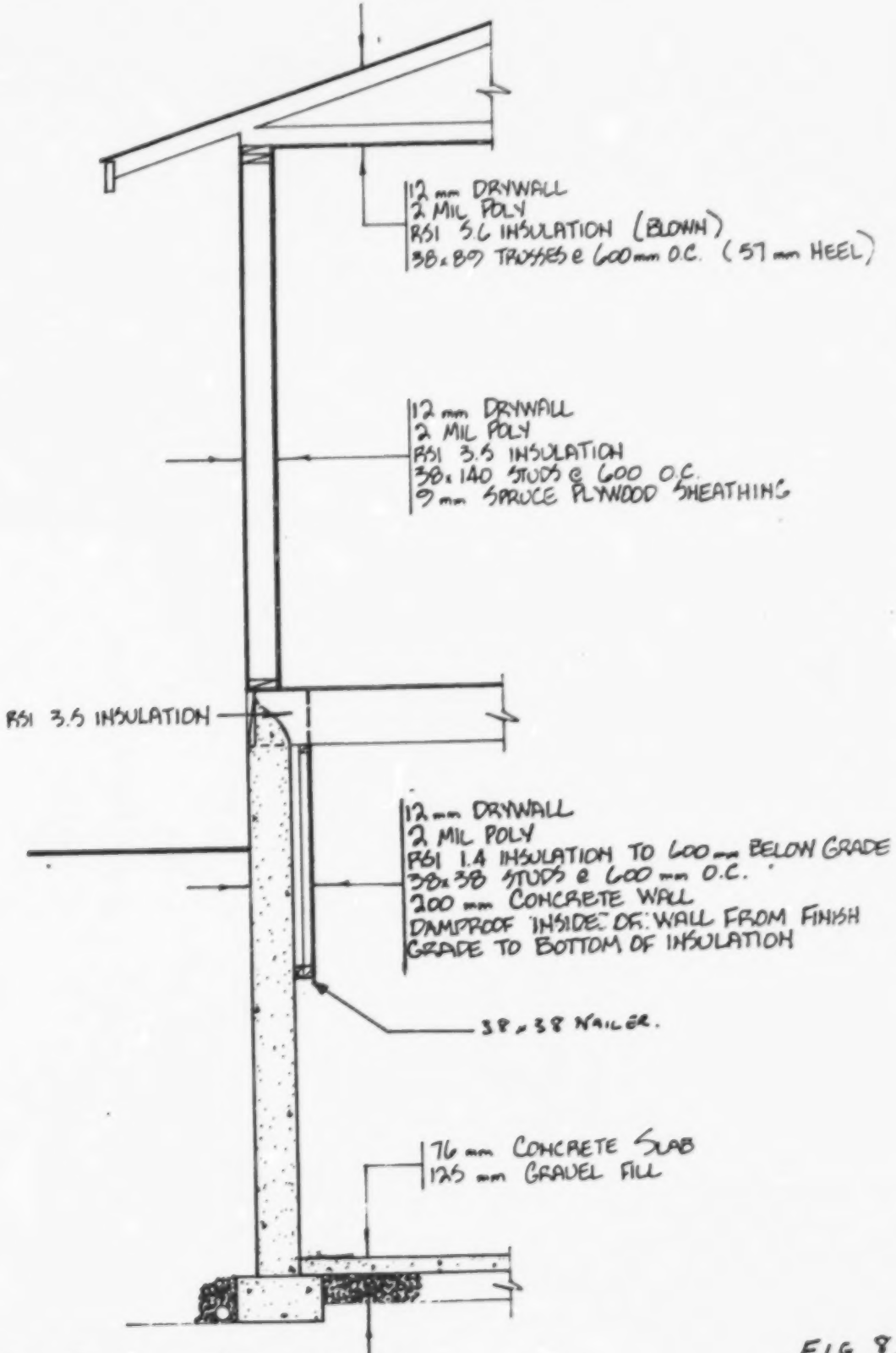
* UPPER FIGURES ARE DAWSON CREEK + 0%
* LOWER FIGURES ARE DAWSON CREEK + 20% (Rounded to the nearest $1,000)

FIG. 6 UNIT FINANCING DETAILS, 1975 STANDARD RESIDENTIAL UNITS AT TUMBLER RIDGE.



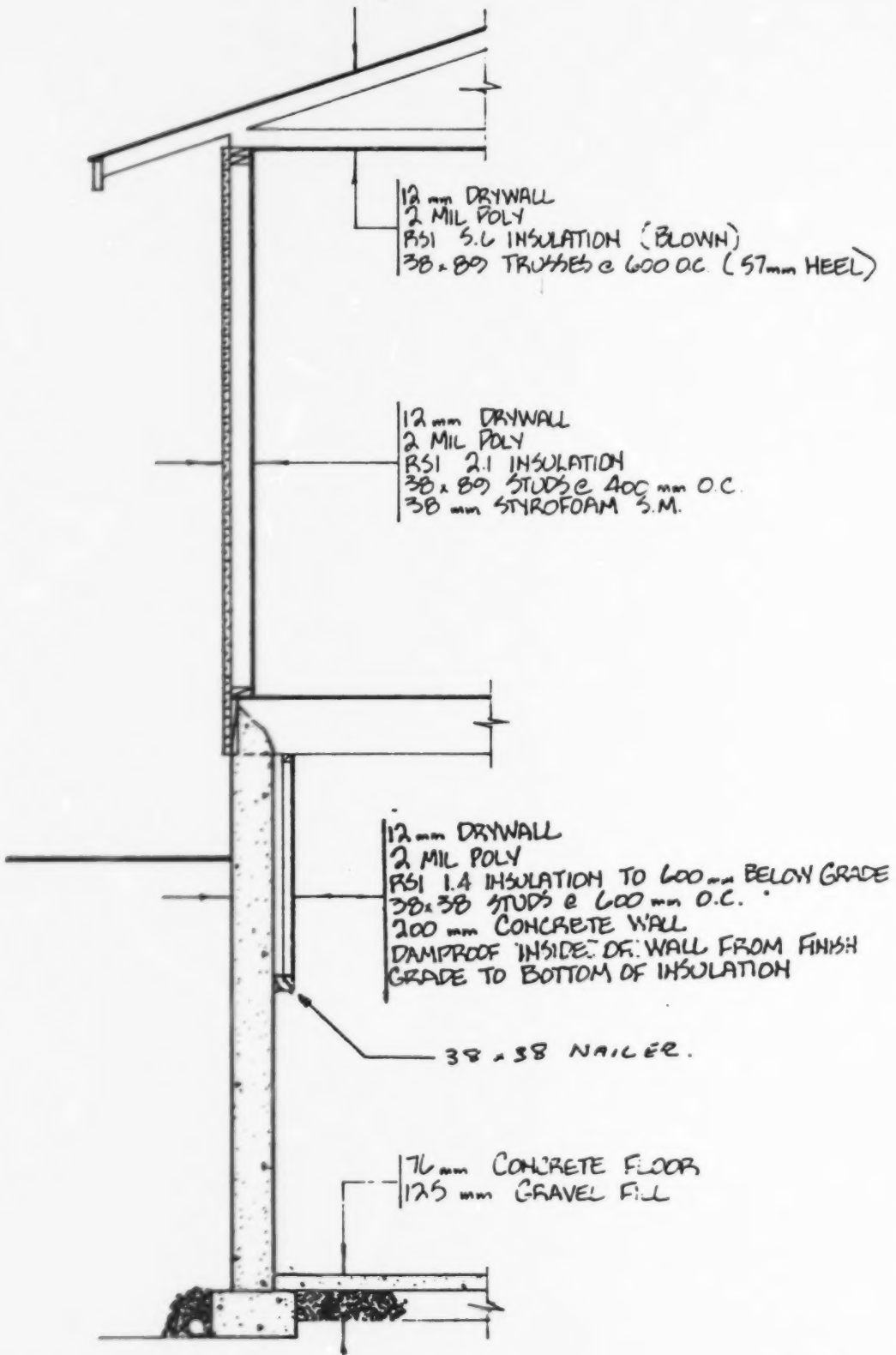
TUMBLER RIDGE - STANDARD

FIG 7.


12 mm DRYWALL
2 MIL POLY
RSI 5.6 INSULATION (BLOWN)
38 x 89 TRUSSES @ 600 mm O.C. (57 mm HEEL)
12 mm DRYWALL
2 MIL POLY
RSI 3.5 INSULATION
38 x 140 STUDS @ 600 O.C.
9 mm SPRUCE PLYWOOD SHEATHING
RSI 3.5 INSULATION
12 mm DRYWALL
2 MIL POLY
RSI 1.4 INSULATION TO 600 mm BELOW GRADE
38 x 38 STUDS @ 600 mm O.C.
200 mm CONCRETE WALL
DAMPROOF INSIDE OF WALL FROM FINISH GRADE TO BOTTOM OF INSULATION
38 x 38 NAILER.
76 mm CONCRETE SLAB
125 mm GRAVEL FILL

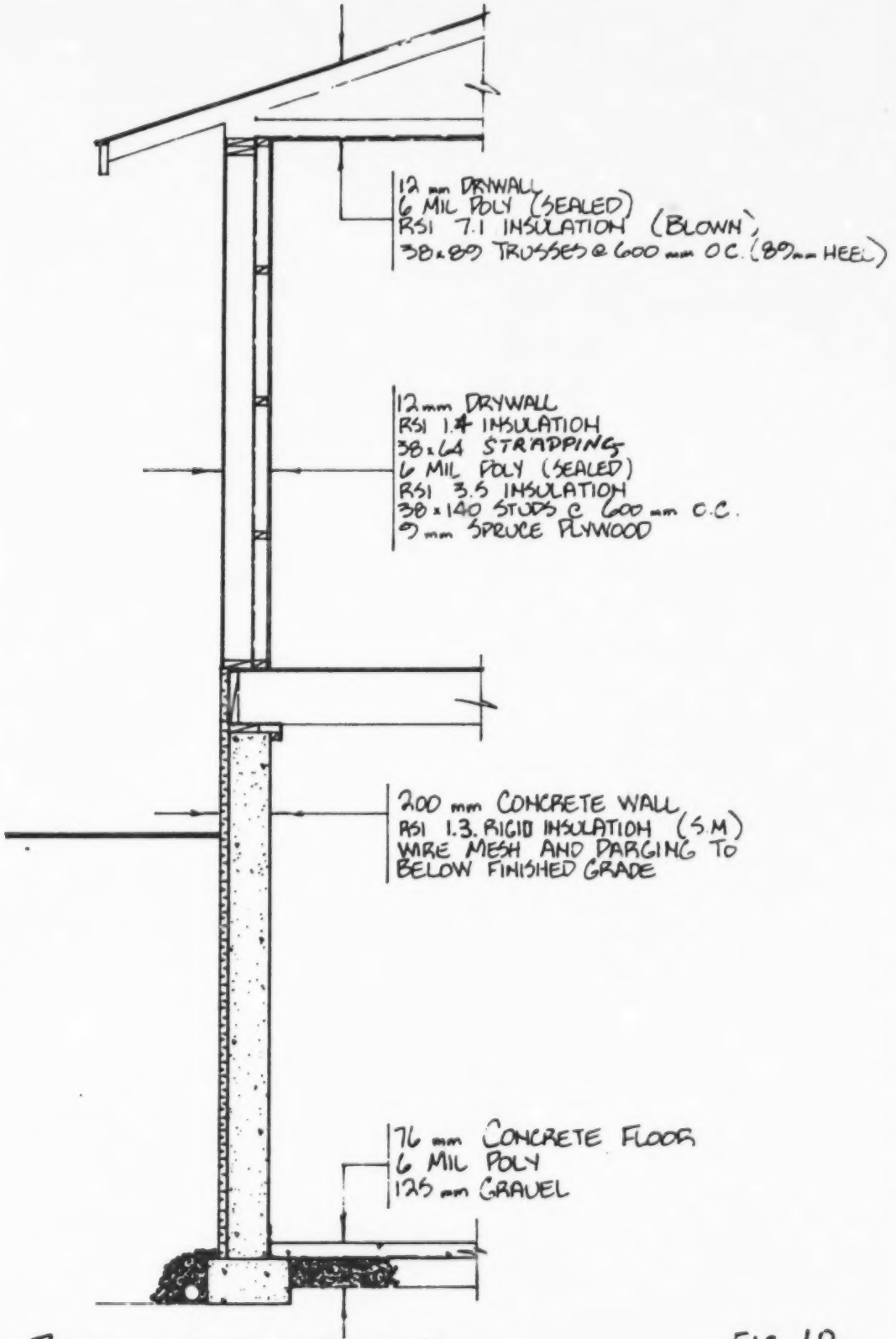
TUMBLER RIDGE - MEASURES '1'

FIG 8.


12 mm DRYWALL
2 MIL POLY
RSI 5.6 INSULATION (BLOWN)
38 x 89 TRUSSES @ 600 OC (57mm HEEL)
12 mm DRYWALL
2 MIL POLY
RSI 2.1 INSULATION
38 x 89 STUDS @ 400 mm O.C.
38 mm STYROFOAM S.M.
12 mm DRYWALL
2 MIL POLY
RSI 1.4 INSULATION TO 600 mm BELOW GRADE
38 x 38 STUDS @ 600 mm O.C.
200 mm CONCRETE WALL
DAMPROOF INSIDE OF WALL FROM FINISH
GRADE TO BOTTOM OF INSULATION
38 x 38 NAILER.
76 mm CONCRETE FLOOR
125 mm GRAVEL FILL

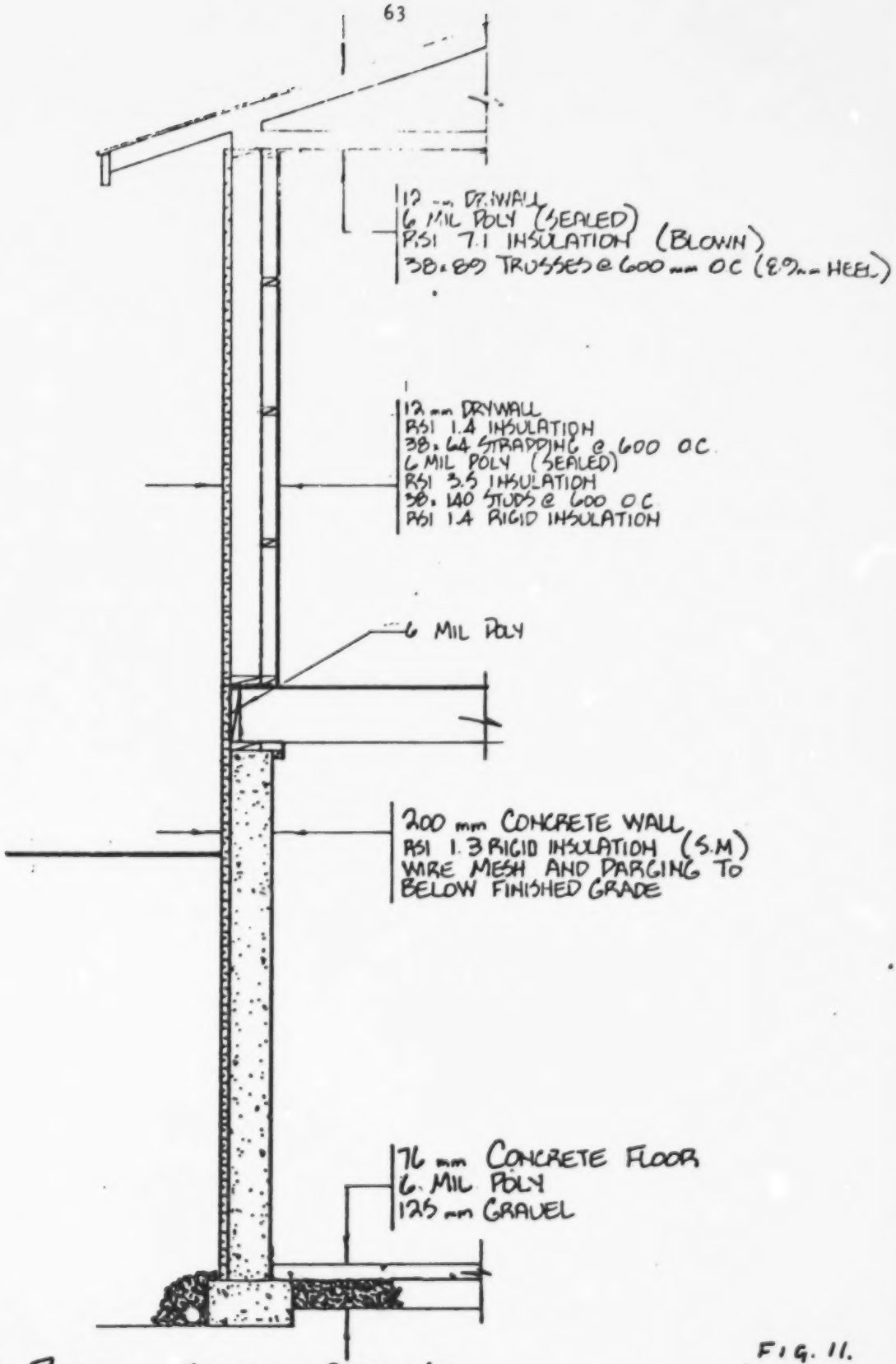
TUMBLER RIDGE – MEASURES '2'

FIG 9.



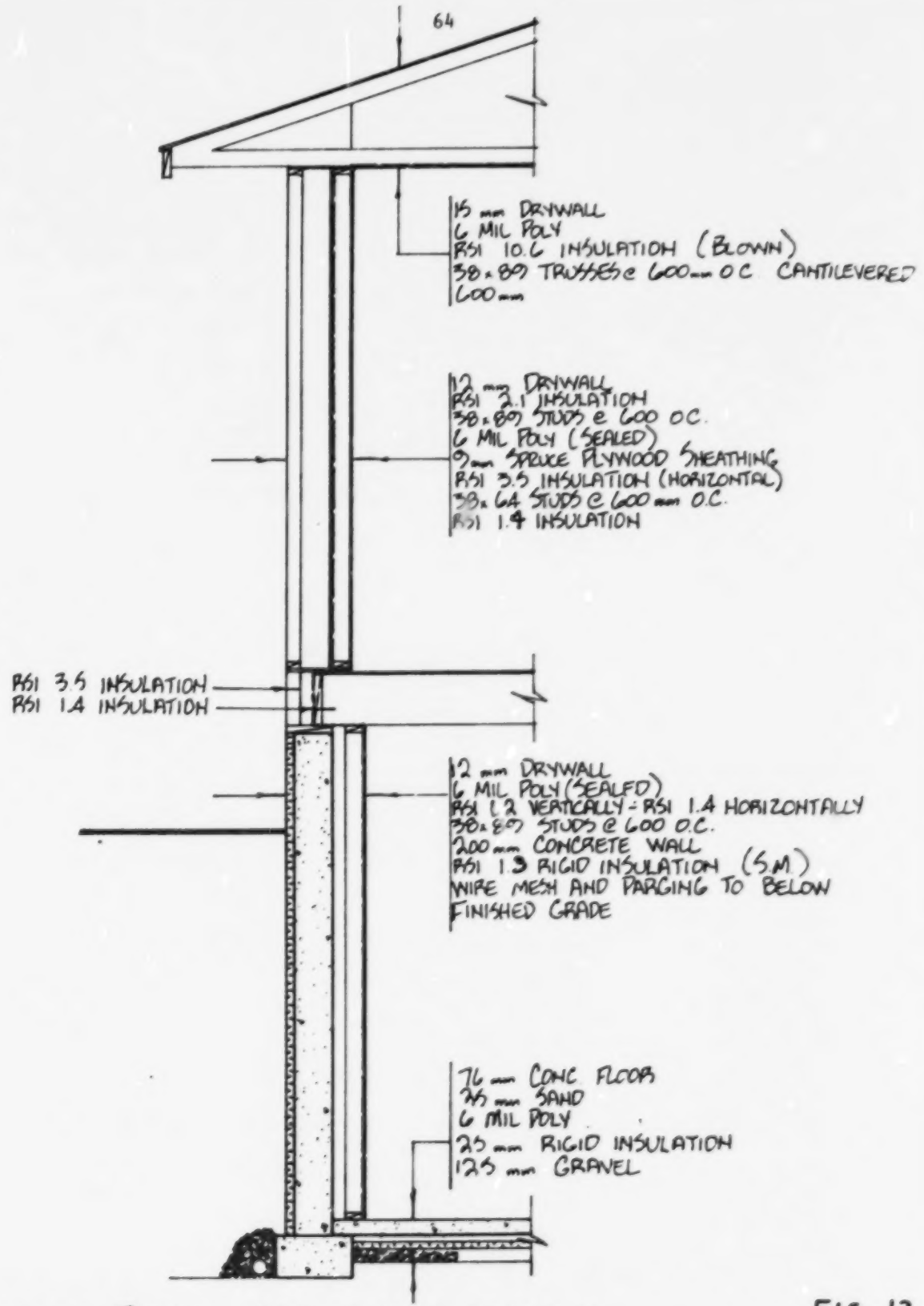
TUMBLER RIDGE – RETROFIT READY '1'

FIG. 10.


12 mm DRYWALL
6 MIL POLY (SEALED)
RSI 7.1 INSULATION (BLOWN)
38x89 TRUSSES @ 600 mm OC (89mm HEEL)
12 mm DRYWALL
RSI 1.4 INSULATION
38x64 STRAPPING @ 600 OC
6 MIL POLY (SEALED)
RSI 3.5 INSULATION
38x140 STUDS @ 600 OC
RSI 1.4 RIGID INSULATION
6 MIL POLY
200 mm CONCRETE WALL
RSI 1.3 RIGID INSULATION (S.M)
WIRE MESH AND PARGING TO
BELOW FINISHED GRADE
76 mm CONCRETE FLOOR
6 MIL POLY
125 mm GRAVEL

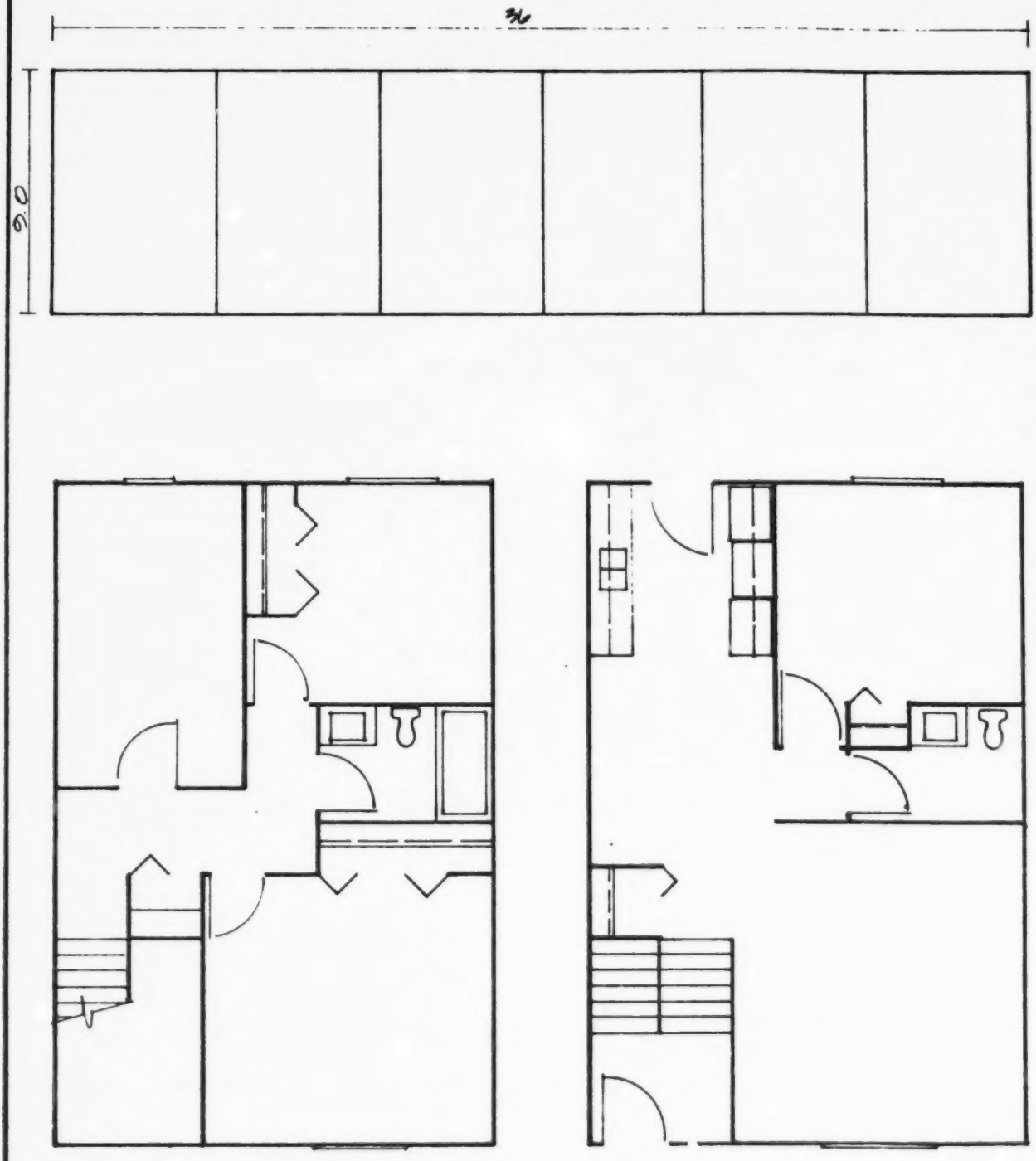
TUMBLER RIDGE – RETROFIT READY '2'

FIG. 11.


15 mm DRYWALL
6 MIL POLY
RSI 10.6 INSULATION (BLOWN)
38 x 89 TRUSSES @ 600 mm O.C. CANTILEVERED
600 mm
12 mm DRYWALL
RSI 2.1 INSULATION
38 x 89 STUDS @ 600 O.C.
6 MIL POLY (SEALED)
9 mm SPRUCE PLYWOOD SHEATHING
RSI 3.5 INSULATION (HORIZONTAL)
38 x 64 STUDS @ 600 mm O.C.
RSI 1.4 INSULATION
RSI 3.5 INSULATION
RSI 1.4 INSULATION
12 mm DRYWALL
6 MIL POLY (SEALED)
RSI 1.2 VERTICALLY - RSI 1.4 HORIZONTALLY
38 x 89 STUDS @ 600 O.C.
200 mm CONCRETE WALL
RSI 1.3 RIGID INSULATION (S.M.)
WIRE MESH AND PARGING TO BELOW
FINISHED GRADE
76 mm CONC FLOOR
25 mm SAND
6 MIL POLY
25 mm RIGID INSULATION
125 mm GRAVEL

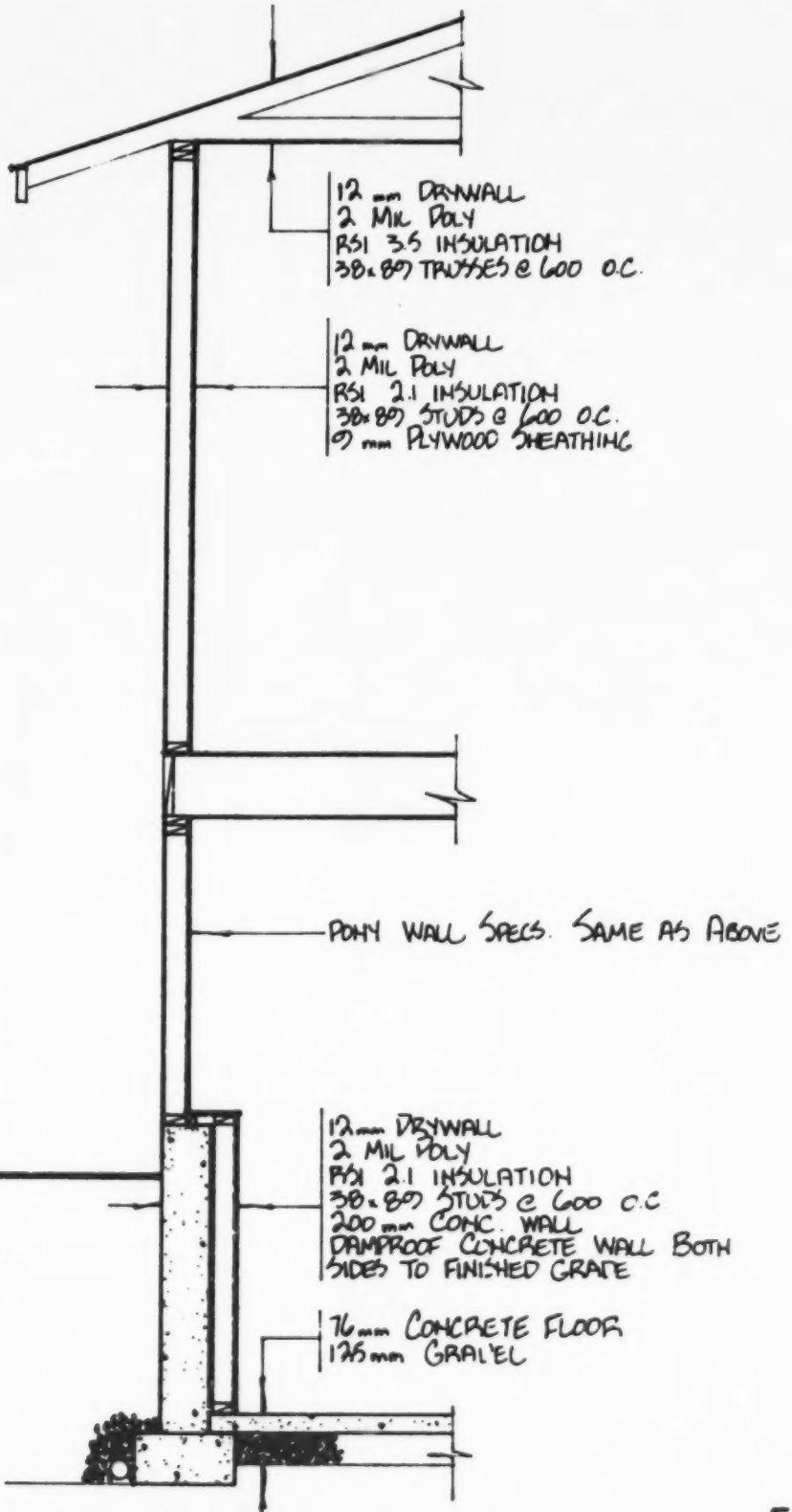
TUMBLER RIDGE - SUPER ENERGY EFFICIENT

FIG. 12.



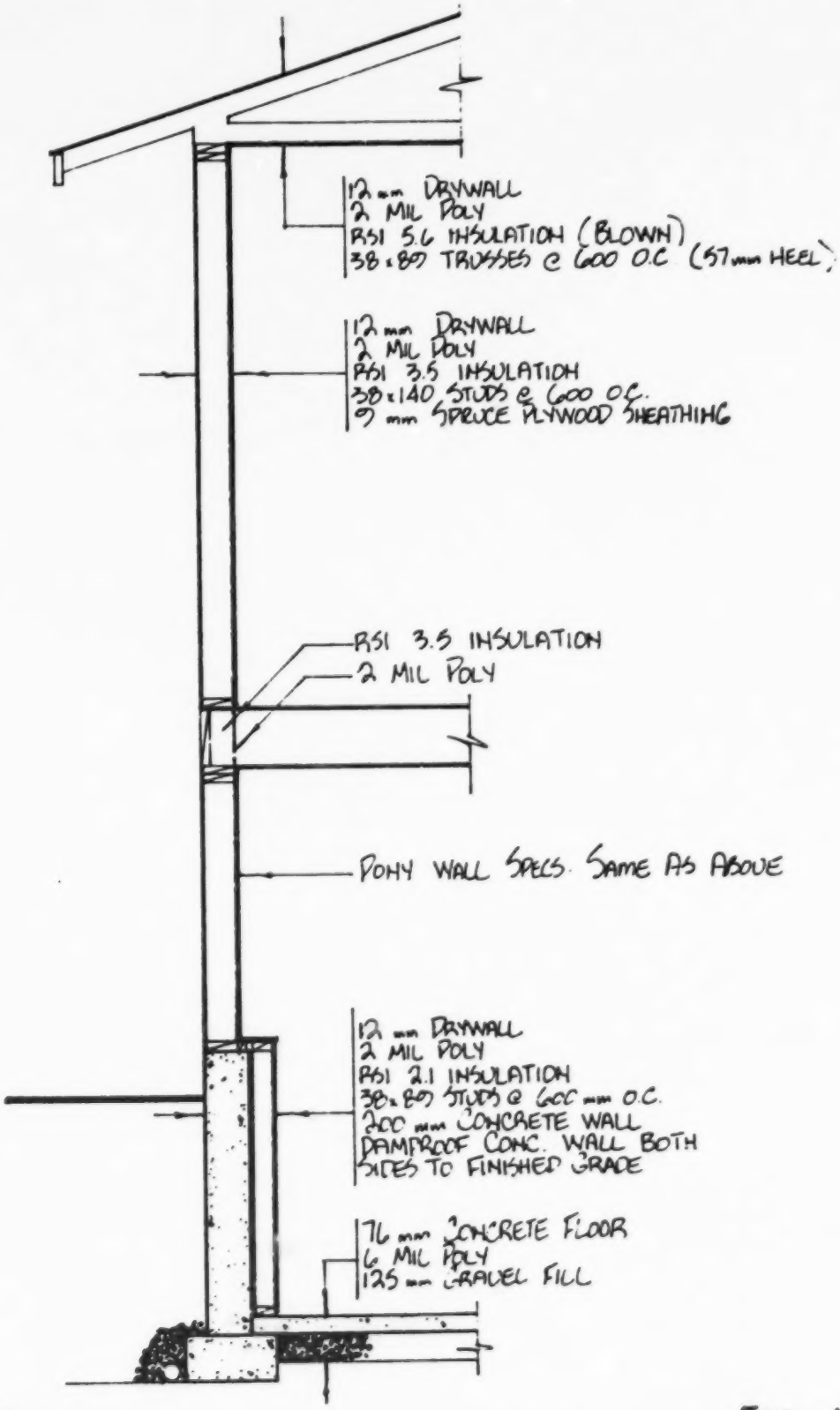
TUMBLER RIDGE - ROW HOUSE BI-LEVEL UNITS

FIG. 13



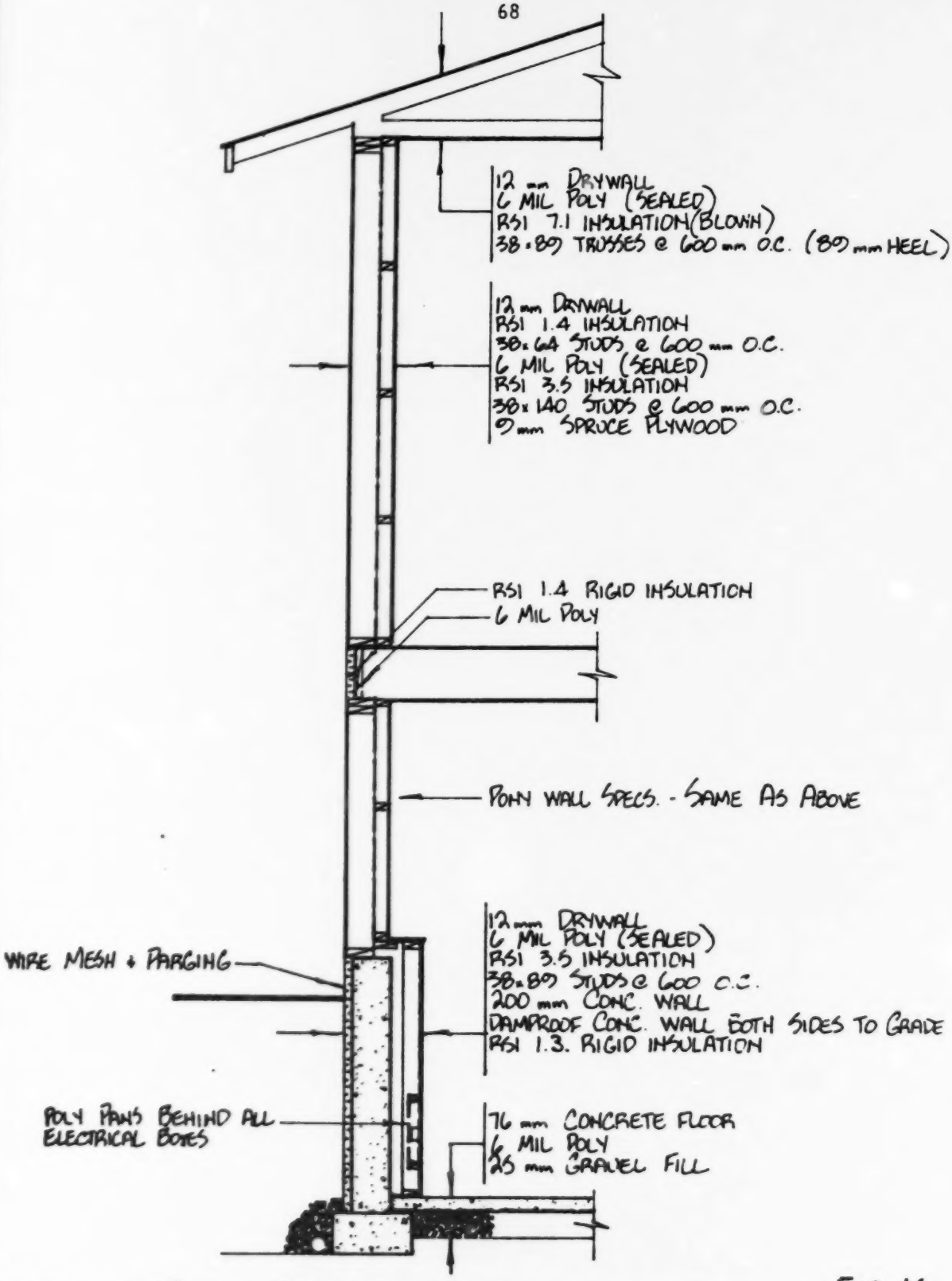
TUMBLER RIDGE - STANDARD

FIG. 14.


12 mm DRYWALL
2 MIL POLY
RSI 5.6 INSULATION (BLOWN)
38 x 89 TRUSSES @ 600 O.C (57mm HEEL)
12 mm DRYWALL
2 MIL POLY
RSI 3.5 INSULATION
38 x 140 STUDS @ 600 O.C.
9 mm SPRUCE PLYWOOD SHEATHING
RSI 3.5 INSULATION
2 MIL POLY
POHY WALL SPECS. SAME AS ABOVE
12 mm DRYWALL
2 MIL POLY
RSI 2.1 INSULATION
38 x 89 STUDS @ 600 mm O.C.
200 mm CONCRETE WALL
DAMPROOF CONC. WALL BOTH
SIDES TO FINISHED GRADE
76 mm CONCRETE FLOOR
6 MIL POLY
125 mm GRAVEL FILL

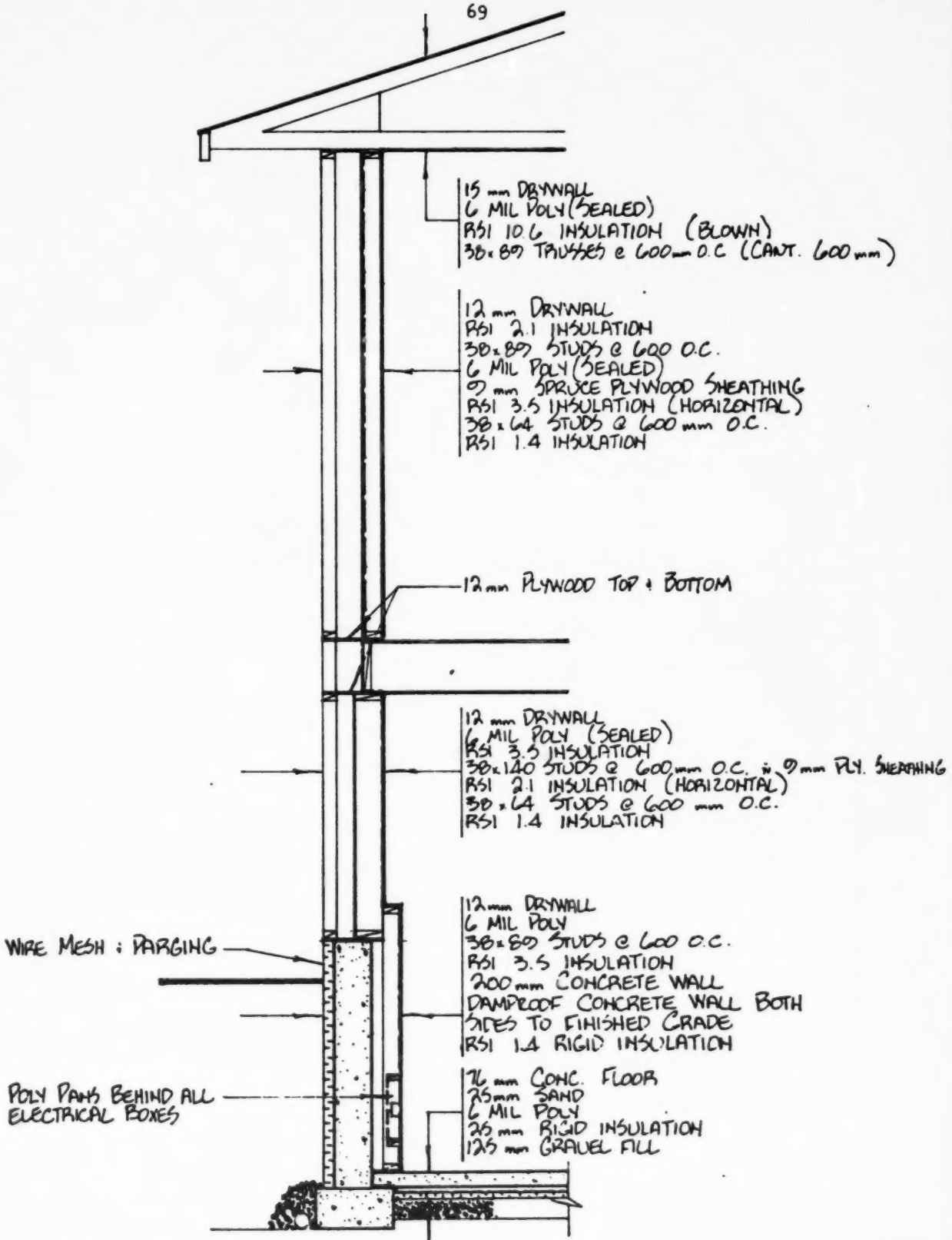
TUMBLER RIDGE: MEASURES

FIG. 15.


12 mm DRYWALL
6 MIL POLY (SEALED)
RSI 7.1 INSULATION (BLOWN)
38 x 89 TRUSSES @ 600 mm O.C. (89 mm HEEL)
12 mm DRYWALL
RSI 1.4 INSULATION
38 x 64 STUDS @ 600 mm O.C.
6 MIL POLY (SEALED)
RSI 3.5 INSULATION
38 x 140 STUDS @ 600 mm O.C.
9 mm SPRUCE PLYWOOD
RSI 1.4 RIGID INSULATION
6 MIL POLY
POWER WALL SPECS. - SAME AS ABOVE
12 mm DRYWALL
6 MIL POLY (SEALED)
RSI 3.5 INSULATION
38 x 89 STUDS @ 600 O.C.
200 mm CONC. WALL
DAMPROOF CONC. WALL BOTH SIDES TO GRADE
RSI 1.3. RIGID INSULATION
WIRE MESH + PARGING
POLY PANS BEHIND ALL ELECTRICAL BOXES
76 mm CONCRETE FLOOR
6 MIL POLY
25 mm GRAVEL FILL

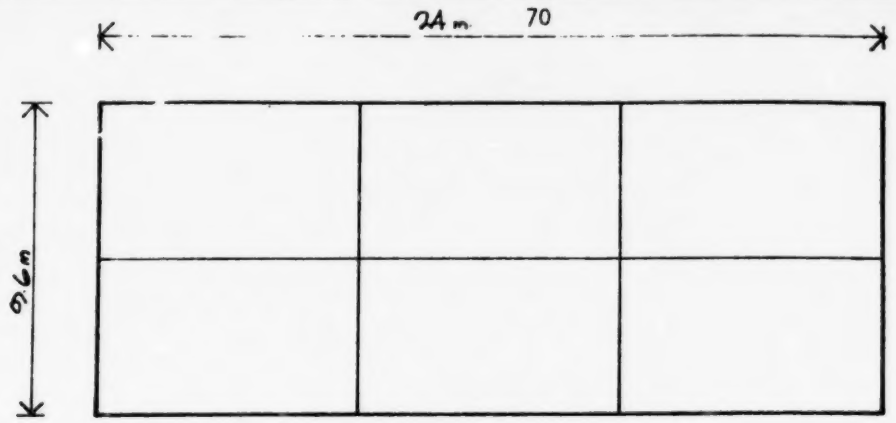
TUMBLER RIDGE: RETROFIT READY

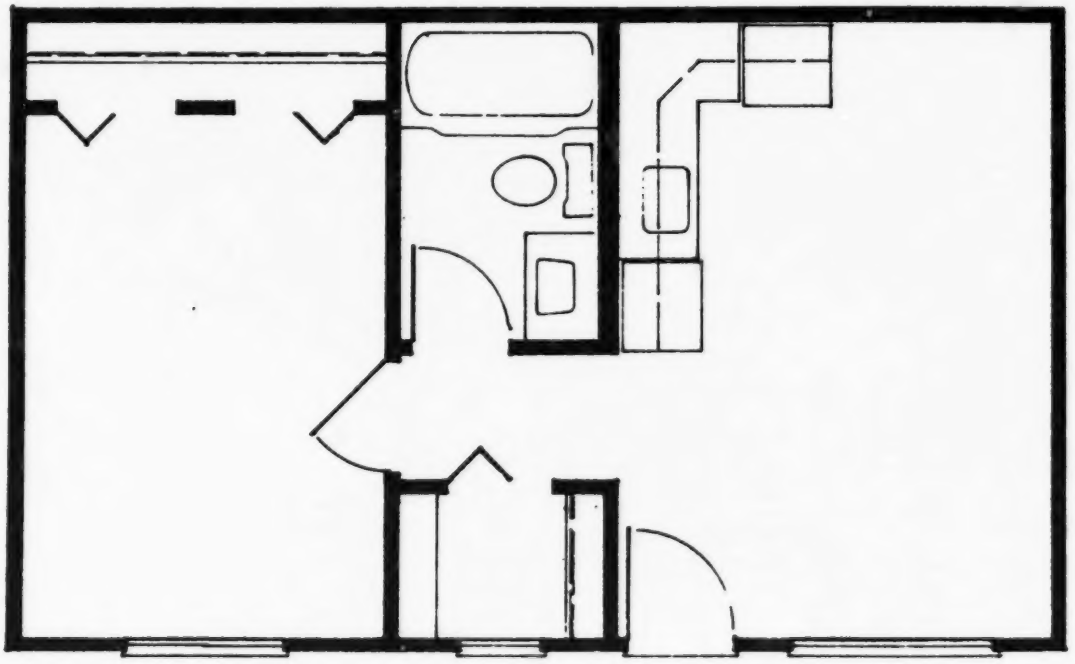
FIG. 16.


15 mm DRYWALL
6 MIL POLY (SEALED)
RSI 10.6 INSULATION (BLOWN)
38 x 89 TRUSSES @ 600 mm O.C (CANT. 600 mm)
12 mm DRYWALL
RSI 2.1 INSULATION
38 x 89 STUDS @ 600 O.C.
6 MIL POLY (SEALED)
9 mm SPRUCE PLYWOOD SHEATHING
RSI 3.5 INSULATION (HORIZONTAL)
38 x 64 STUDS @ 600 mm O.C.
RSI 1.4 INSULATION
12 mm PLYWOOD TOP & BOTTOM
12 mm DRYWALL
6 MIL POLY (SEALED)
RSI 3.5 INSULATION
38 x 140 STUDS @ 600 mm O.C. & 9 mm PLY. SHEATHING
RSI 2.1 INSULATION (HORIZONTAL)
38 x 64 STUDS @ 600 mm O.C.
RSI 1.4 INSULATION
12 mm DRYWALL
6 MIL POLY
38 x 89 STUDS @ 600 O.C.
RSI 3.5 INSULATION
200 mm CONCRETE WALL
DAMPROOF CONCRETE WALL BOTH SIDES TO FINISHED GRADE
RSI 1.4 RIGID INSULATION
WIRE MESH & PARGING
POLY PANS BEHIND ALL ELECTRICAL BOXES
76 mm CONC. FLOOR
25 mm SAND
6 MIL POLY
25 mm RIGID INSULATION
125 mm GRAVEL FILL

TUMBLE RIDGE: SUPER ENERGY EFFICIENT

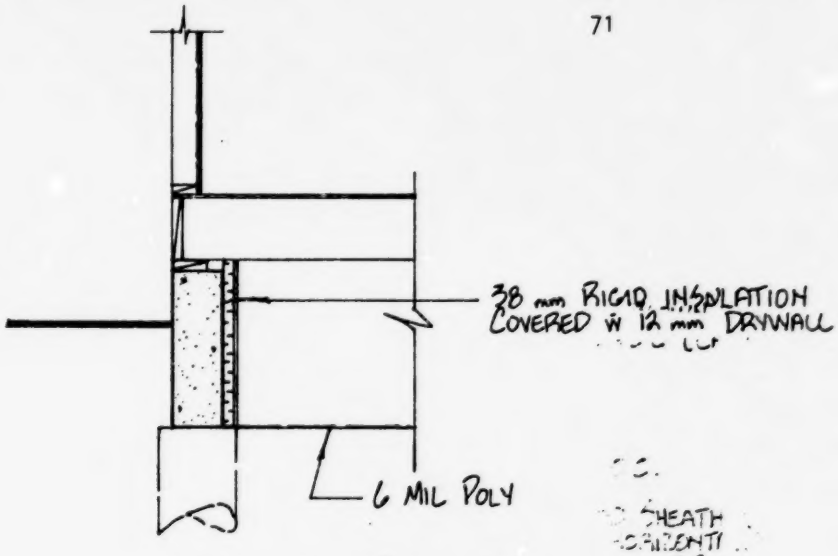
FIG. 17.



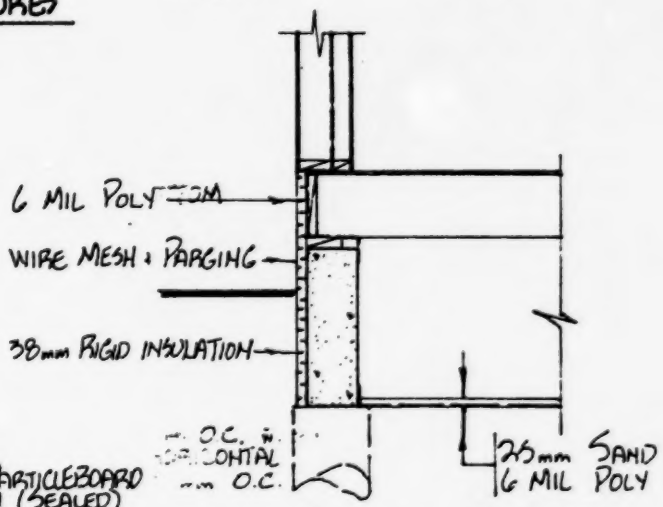


TUMBLER RIDGE - APARTMENT

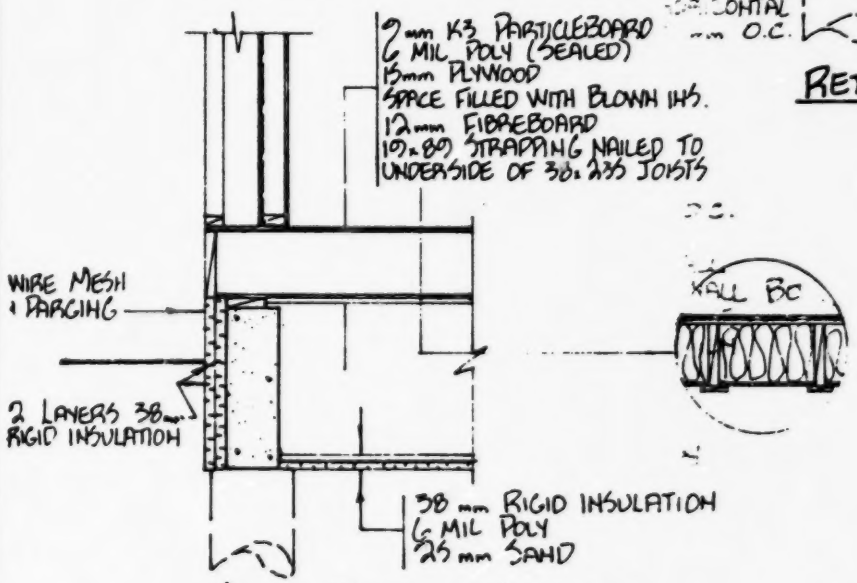
FIG. 18



STANDARD & MEASURES



RETROFIT READY



SUPER ENERGY EFFICIENT

FIG. 19.

TUMBLER RIDGE

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R.R. #1	R.R. #2	SEE #1	SEE #2
100 m^2 DETACHED	0	1,512	1,528	1,994	4,479	4,939	10,804	11,233
80.6 m^2 DETACHED	0	1,320	1,335	1,753	3,960	4,374	9,634	9,973
96 m^2 SEMI-DETACHED	0	1,257	1,270	1,609	2,826	4,167	9,371	9,783
75 m^2 SEMI-DETACHED	0	1,051	1,062	1,362	3,161	3,458	8,160	8,474
54 m^2 ROW UNIT	0	589	581	N.A.	2,491	2,619	5,729	5,968
38.4 m^2 APARTMENT	0	305	310	N.A	1,197	1,308	3,361	N.A
PRE-BUILT	0	1,192		1,525				

FIG. 20 INCREMENTAL COSTS AT TUMBLER RIDGE

		MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1	SEE #2
100 m^2 DETACHED	DOWN P.I.	378 17	382 17	499 22	1120 49	1235 54	2701 119	2808 124
80.6 m^2 DETACHED	DOWN P.I.	330 15	334 15	438 19	990 44	1094 48	2409 106	2493 110
96 m^2 SEMI-DETACHED	DOWN P.I.	314 14	318 14	402 18	957 42	1042 46	2343 103	2446 108
75 m^2 SEMI-DETACHED	DOWN P.I.	263 12	266 12	341 15	790 35	865 38	2040 90	2119 93
54 m^2 ROW	DOWN P.I.	147 6	145 6	N.A.	623 27	655 29	1432 63	1492 66
38.4 m^2 APARTMENT	DOWN P.I.	76 3	78 3	N.A.	299 13	327 14	840 37	N.A.
PRE-BUILT	DOWN P.I.	298 13		381 17				

FIG. 21 INCREMENTAL DOWN PAYMENTS AND MONTHLY P.I. PAYMENTS FOR VARIOUS LEVELS OF ENERGY CONSERVATION.

	MEAS #1	MEAS #2	MEAS #3	R.R. #1	R.R. #2	SEE #1	SEE #2
100 m^2 DETACHED	$1,942	1,963	2,561	5,754	6,344	13,878	14,430
80.6 m^2 DETACHED	1,696	1,715	2,252	5,087	5,619	12,375	12,811
96 m^2 SEMI-DETACHED	1,615	1,631	2,067	4,915	5,353	12,038	12,567
75 m^2 SEMI-DETACHED	1,350	1,364	1,750	4,061	4,442	10,482	10,885
56 m^2 ROW	757	746	N.A	3,200	3,364	7,359	7,666
38.4 m^2 APARTMENT	382	398	N.A	1,538	1,680	4,317	N.A
PRE-BUILT	1,531		1,959				

FIG. 22 PRESENT WORTH OF INCREMENTAL CONSTRUCTION COSTS

	ANNUAL SPACE HEAT NEED (GJ/yr/unit)						
	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	171	103	104	91	60	58	22
SMALL DETACHED	144	85	85	74	49	47	17
LARGE DUPLEX	146	91			53	52	21
SMALL DUPLEX	110	64			35	33	10
ROW	53	36			19	18	6
APARTMENT	24	17			9	9	2
PRE-BUILT	225	113					

FIG. 23 ANNUAL SPACE HEAT NEEDS OF VARIOUS UNITS.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	$ 85	54	54	48	33	32	13
SMALL DETACHED	73	45	45	40	27	26	10
LARGE SEMI-DETACHED	74	48			29	29	12
SMALL SEMI-DETACHED	57	35			20	19	6
ROW	29	20			11	10	4
APARTMENT	14	10			5	5	1
PRE-BUILT	110	59					

FIG.24 AVERAGE MONTHLY FUEL BILLS WITH NATURAL GAS HEATING AND 60% EFFICIENT FURNACE. (1982 RATES).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	0	31	31	37	52	53	72
SMALL DETACHED	0	28	28	33	46	47	63
LARGE SEMI-DETACHED	0	26			45	45	62
SMALL SEMI-DETACHED	0	22			37	38	51
ROW	0	9			18	19	25
APARTMENT	0	4			9	9	13
PRE-BUILT	0	51					

FIG. 25 MONTHLY FUEL BILL SAVINGS, (NATURAL GAS AT 1982 RATES WITH 60% EFFICIENT FURNACE.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	-14	-14	-15	-3	+1	+47
SMALL DETACHED	--	-13	-13	-14	-2	+1	+43
LARGE SEMI-DETACHED	--	-12			-3	+1	+41
SMALL SEMI-DETACHED	--	-10			-2	0	+39
ROW	--	-3			+9	+10	+38
APARTMENT	--	-1			+4	+5	+24
PRE-BUILT	--	-38					

FIG. 26 MONTHLY P.I.T.H. INCREMENT RELATIVE TO 1975 STANDARD (FOR NATURAL GAS, 1982 RATES, 60% EFFICIENT FURNACE).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	$12445	12268	14560	19967	20314	26598
SMALL DETACHED	--	10560	10560	12480	16826	17173	22430
LARGE SEMI-DETACHED	--	9877			16500	16673	22091
SMALL SEMI-DETACHED	--	8069			13114	13463	17524
ROW	--	2959			5944	6121	8260
APARTMENT	--	1237			2661	2661	3919
PRE-BUILT	--	21316					

FIG.27 PRESENT WORTH OF FUEL SAVINGS (FOR NATURAL GAS WITH 60% EFFICIENT FURNACE.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	10503	10305	11999	14213	13970	12720
SMALL DETACHED	--	8864	8845	10228	11739	11554	10055
LARGE SEMI-DETACHED	--	8262			11585	11320	10053
SMALL SEMI-DETACHED	--	6719			9053	9021	7042
ROW	--	2202			2744	2757	901
APARTMENT	--	845			1123	981	-398
PRE-BUILT	--	19785					

FIG.28 COMBINED PRESENT WORTH OF ENERGY CONSERVATION MEASURES (NATURAL GAS, WITH 60% EFFICIENT FURNACE).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #3
LARGE DETACHED	$ 74	47	47	42	28	27	11
SMALL DETACHED	63	39	39	34	23	23	8
LARGE SEMI-DETACHED	64	42			25	25	10
SMALL SEMI-DETACHED	50	30			17	16	5
ROW	25	17			9	9	3
APARTMENT	12	8			5	5	1
PRE-BUILT	95	51					

FIG.29 AVERAGE MONTHLY FUEL BILLS WITH NATURAL GAS HEATING, 1982 RATES, AND 70% EFFICIENT FURNACE.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	27	27	32	46	47	63
SMALL DETACHED	--	24	24	29	40	40	55
LARGE SEMI-DETACHED	--	22			39	39	54
SMALL SEMI-DETACHED	--	20			33	34	45
ROW	--	8			16	16	22
APARTMENT	--	4			7	7	11
PRE-BUILT	--	44					

FIG.30 MONTHLY FUEL BILL SAVINGS (NATURAL GAS AT 1982 RATES, WITH 70% EFFICIENT FURNACE).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	-10	-10	-10	+ 3	+ 7	+56
SMALL DETACHED	--	- 9	- 9	-10	+ 4	+ 8	+51
LARGE SEMI-DETACHED	--	- 8			+ 3	+ 7	+49
SMALL SEMI-DETACHED	--	- 8			+ 2	+ 4	+45
ROW	--	- 2			+11	+13	+41
APARTMENT	--	- 1			+ 6	+ 7	+26
PRE-BUILT	--	-31					

FIG.31 MONTHLY P.I.T.H. INCREMENT RELATIVE TO 1975 STANDARD (FOR NATURAL GAS, 1982 RATES, 70% EFFICIENT FURNACE).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	$10458	10308	12257	16878	17176	22575
SMALL DETACHED	--	8933	8933	10573	14298	14596	19114
LARGE SEMI-DETACHED	--	8346			14010	14159	18815
SMALL SEMI-DETACHED	--	6877			11208	11509	14999
ROW	--	2542			5109	5261	7099
APARTMENT	--	1062			2286	2286	3366
PRE-BUILT	--	17748					

FIG. 32 PRESENT WORTH OF FUEL SAVINGS (FOR NATURAL GAS WITH 70% EFFICIENT FURNACE).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED		8516	8345	9696	11124	10832	8697
SMALL DETACHED		7237	7218	8321	9211	8977	6739
LARGE SEMI-DETACHED		6731			9095	8806	6777
SMALL SEMI-DETACHED		5527			7147	7067	4517
ROW		1785			1909	1897	-157
APARTMENT		669			748	606	-951
PRE-BUILT		16217					

FIG. 33 COMBINED PRESENT WORTH OF ENERGY CONSERVATION MEASURES (NATURAL GAS, WITH 70% EFFICIENT FURNACE).

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	$ 137	82	83	73	48	46	18
SMALL DETACHED	115	68	68	59	39	38	14
LARGE SEMI-DETACHED	117	73			42	42	17
SMALL SEMI-DETACHED	88	51			28	26	8
ROW	42	29			15	14	5
APARTMENT	19	14			7	7	2
PRE-BUILT	180	90					

FIG. 34 AVERAGE MONTHLY FUEL BILLS WITH ELECTRICAL HEATING AT 1982 RATES.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	55	54	64	89	91	119
SMALL DETACHED	--	47	47	56	76	77	101
LARGE SEMI-DETACHED	--	44			75	75	100
SMALL SEMI-DETACHED	--	37			60	62	80
ROW	--	13			27	28	37
APARTMENT	--	5			12	12	17
PRE-BUILT	--	90					

FIG. 35 MONTHLY FUEL BILL SAVINGS, ELECTRICAL HEATING AT 1982 RATES.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	-38	-37	-42	-40	-37	0
SMALL DETACHED	--	-32	-32	-37	-32	-29	+ 5
LARGE SEMI-DETACHED	--	-30			-33	-29	+ 3
SMALL SEMI-DETACHED	--	-25			-25	-24	+10
ROW	--	- 7			0	+ 1	+26
APARTMENT	--	- 2			+ 1	+ 2	+20
PRE-BUILT	--	-77					

FIG.36 MONTHLY P.I.T.H. INCREMENT, RELATIVE TO 1975 STANDARD FOR ELECTRICAL HEATING, 1982 RATES.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	--	$15497	15215	18033	25077	25640	33529
SMALL DETACHED	--	13243	13243	15779	21414	21696	28458
LARGE SEMI-DETACHED	--	12397			21132	21132	28176
SMALL SEMI-DETACHED	--	10425			16906	17469	22541
ROW	--	3663			7608	7889	10425
APARTMENT	--	1409			3381	3381	4790
PRE-BUILT	--	25358					

FIG. 37 PRESENT WORTH OF FUEL SAVINGS FOR ELECTRICAL HEATING.

	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED		$13555	13252	15472	19323	19296	19651
SMALL DETACHED		11547	11528	13527	16327	16077	16083
LARGE SEMI-DETACHED		10782			16217	15779	16138
SMALL SEMI-DETACHED		9075			12845	13027	12059
ROW		2906			4408	4525	3066
APARTMENT		1017			1843	1701	473
PRE-BUILT		23827					

FIG.38 COMBINED PRESENT WORTH OF ENERGY CONSERVATION MEASURES WITH ELECTRICAL HEATING.

CRITERIA FOR COST EFFECTIVENESS

monthly PIT & present worth

present worth

	ANNUAL SPACE HEAT NEED (GJ/yr/unit)						
	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
LARGE DETACHED	171	103	104	91	60	58	22
SMALL DETACHED	144	85	85	74	49	47	17
LARGE DUPLEX	146	91			53	52	21
SMALL DUPLEX	110	64			35	33	10
ROW	53	36			19	18	6
APARTMENT	24	17			9	9	2
PRE-BUILT	225	113					

FIG. 39 CONFIGURATIONS FOR COST-EFFECTIVE USE OF 70%-EFFICIENT FURNACE

APPENDIX I

DETAILED BREAKDOWN OF INCREMENTAL COSTS OF ENERGY-EFFICIENT CONSTRUCTION (BUILDER COSTS ONLY, SASKATOON CONDITIONS)

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TUMBLER RIDGE, BRITISH COLUMBIA

MATERIAL & LABOR

CONSTRUCTION: STANDARD DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
100 M^2 FSI 3.5 Blown Fiberglass (incl. labor)	100 M^2	3.55	355.00
34 - 1200 x 2400 - 12 mm Drywall	1088	207.05	225.27
Trusses - 38 x 89 - 9.6 M trusses std. heel	16	36.77	588.32
TAX			40.68
- Labor:			
Drywall - 100 M^2 @ 0.86 per M^2			86.00
Frame - 100 M^2 @ 4.30 per M^2			430.00
			1,725.27
WALLS - Material:			
120 38 x 89 plates	263	268	70.48
33 1200 x 2400 - 9mm spr.	33	8.77	289.41
80 38 x 89 - 2316 stds.	427	255	108.89
33 1200 x 2400 - 12mm drywall	1056	207.05	218.64
TAX			34.37
- Labor:			
Drywall - 96 M^2 @ 0.86 per M^2			82.56
Insulation - 86.4 M^2 @ 2.53 per M			218.59
Frame - 100 M^2 @ 6.46 per M^2			646.00
			1,668.94
BASEMENT - Material:			
120 M 38 x 38 spr. plates	263	319	83.90
80 38 x 38 - 1.2 M spr. studs	214	210	44.99
17 1200 x 2400 - 12mm Drywall	544	207.05	112.64
TAX			14.31

	AMOUNT	PRICE	EXTENSION
BASEMENT - Labor: (cont'd)			
Drywall - 48 M^2 @ .86 per M^2			41.28
Tar - 24 M^2 @ 1.61 per M^2			38.64
RSI 1.4 Insulation - 48 M^2 @ 1.94 per M^2			93.12
Frame - 40 M @ 1.64 per M			65.60
			494.48
Costs per M^2 = Ceiling - (99.84) $ 17.28			
Walls - (96) $ 17.38			
Basement- (96) $ 5.67			
- used full height basement for M^2 cost			
- based on bungalow - 99.84 M^2 (9.6 x 10.4)			

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: STANDARD

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
1 roll 2M x 1500 poly	1	14.28	14.28
TAX			.71
- Labor:			
100 M^2 @ .11 per M^2			11.00
			25.99
WALLS - Material:			
1 roll 2M x 1500 poly	1	14.28	14.28
TAX			.71
- Labor:			
96 M @ .11 per M			10.86
			25.85
BASEMENT - Material:			
.5 roll 2M x 1500 poly	.5	14.28	7.14
TAX			.35
- Labor:			
48 M^2 @ .11 per M^2			5.28
			12.77
TOTAL			$ 64.61
Poly Cost per M^2 = Ceiling (99.84) $ .26			
Walls (96) $ .27			
Basement (96) $ .13			

TUMBLER RIDGE, BRITISH COLUMBIA

DOORS & WINDOWS

CONSTRUCTION: STANDARD

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
DOORS - 2 s.c. wood doors	2	182.00	364.00
TAX			18.20
			382.20
WINDOWS - Dashwood - wood			
- 4 3/8 jams			
- Dual Glazed			
Bedrooms - 3 2W2 (185.72)	3	185.72	557.16
Bathroom - 1 2924A	1		107.83
Kitchen - 1 4130A	1		151.12
Liv. Rm. - 1 30 x 30 x 30/60 S.V.	1		298.68
			1,114.79
			55.74
			1,170.53

MEASURES - METHOD (a) CONSTRUCTION: MEASURES

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
16 high heel Trusses	16	38.27	612.32
100 M^2 RSI 5.6 blown insulation (labor incl.)	100	5.60	560.00
34 - 1200 x 2400 - 12mm drywall	1088	207.05	225.27
TAX			41.88
- Labor:			
Drywall - 100 M^2 @ .86			86.00
Frame - 100 M^2 @ 4.30			430.00
			1,955.47
WALLS - Material:			
120 M 38 x 140 plates	394	281	110.71
80 38 x 140 studs	640	274	175.36
33 1200 x 2400 - 9 mm spr.	33	8.77	289.41
33 1200 x 2400 - 12 mm drywall	1056	207.05	218.64
TAX			39.71
- Labor:			
Drywall - 96 M^2 @ .86 per M^2			82.56
Insulation - 86.4 M^2 @ 3.71 per M^2			320.54
Header Insulation - 9.6 M^2 @ 2.53			24.29
Frame - 100 M^2 @ 6.46 per M^2			646.00
			1,907.22
BASEMENT - Material:			
77 M 38 x 38 spr.	84	319	26.80
80 38 x 38 - 2.4 M studs	428	210	89.88
17 1200 x 2400 - 12 mm Drywall	544	207.05	112.64
TAX			9.22
- Labor:			
Drywall - 96 M^2 @ .86 per M^2			82.56
RSI 1.4 Insulation - 96 M^2 @ 1.94			186.24

MEASURES - Method (a) CONSTRUCTION: MEASURES

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
BASEMENT - Labor: (cont'd)			
Frame - 40 M @ 2.30			92.00
Tar - 72 M^2 @ 1.61			115.92
			715.26
Costs per M^2 = Ceiling (97.84) $ 19.59			
Walls (96) $ 19.87			
Basement (96) $ 6.98			
- used full basement height for M^2 cost			
- used header insulation in wall cost			
MEASURES - Method (b) - walls only:			
WALLS - Material:			
120 M 38 x 89 spr. plates	263	268	70.48
120 38 x 89 spr. studs	640	255	163.20
33 1200 x 2400 - 38 mm SM	1050	420	443.52
8 38 mm x 3.0 M metal braces	80	.10	8.00
33 1200 x 2400 - 12 mm drywall	1056	207.05	218.64
TAX			45.19
- Labor:			
Drywall - 96 M^2 @ .86 per M^2			82.56
Insulation - 86.4 M^2 @ 2.53 per M^2			218.59
Header Insulation - 9.6 M^2 @ 2.53			24.29
Frame - 100 M^2 @ 6.46 per M^2			646.00
			1,920.47
Walls cost per M^2 = (96) $ 20.00			

TUMBLER RIDGE, BRITISH COLUMBIA

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VAPOR BARRIER

CONSTRUCTION: MEASURES

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
1 roll 2M x 1500 poly	1	14.28	14.28
TAX			.71
- Labor:			
100 M^2 @ .11			11.00
			25.99
WALLS - Material:			
1 roll 2M x 1500 poly	1	14.28	14.28
TAX			.71
Header poly			30.00
- Labor:			
96 M^2 @ .11			10.56
			55.55
BASEMENT - Material:			
1 roll 2 M x 1500 poly	1	14.28	14.28
TAX			.71
- Labor:			
96 M^2 @ .11			10.56
			25.85
TOTAL			107.39.
Poly cost per M^2 = Ceiling (99.84) $ .26			
Walls (96) $ .58			
Basement (96) $ .27			
Assume: poly material same as for standard except			
in basement and header area.			

TUMBLER RIDGE, BRITISH COLUMBIA

DOORS & WINDOWS

CONSTRUCTION: MEASURES

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
DOORS - 2 s.c. wood doors	2	182.00	364.00
6 3/8 jamb	2	20.00	40.00
			404.00
TAX			20.20
			424.20
WINDOWS - wood			
- dual glazed			
- 6 3/8 jamb			
Basic			1,114.79
6 3/8 jamb			162.95
			1,277.74
TAX			63.89
			1,341.63

MATERIAL & LABOR CONSTRUCTION: RETRO-FIT READY

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
WALLS - Material:			
120 M 38 x 140 spr. plates	394	281	110.71
80 38 x 140 spr. studs	640	274	175.36
33 1200 x 2400 - 9mm spr.	33	8.77	289.41
40 M 38 x 140 spr. mud sill	131	287	36.81
200 M 38 x 64 spr.	328	274	89.87
33 1200 x 2400 - 12 mm Drywall	1056	207.05	218.64
TAX			46.04
Labor:			
Drywall - 96 M^2 @ .86 per M^2			82.56
RSI 3.5 Insulation O.S. - 86.4 @ 3.71			320.54
RSI 1.4 Insulation I.S. - 86.4 @ 1.94			167.62
Frame - O.S. 100 M^2 @ 6.46			646.00
I.S. 100 M^2 @ 1.08			108.00
			2,291.56
CEILING - Material:			
16 - 38 x 89 - 9.6 spr. trusses 89mm heel	16	40.27	636.82
100 M^2 RSI 7.1 blown insulation	100	6.62	662.00
34 1200 x 2400 - 15mm Drywall	1088	268.39	292.01
32 Baffles @ .25 diff.	32	.25	8.00
(Chimney) .5 - 1200 x 2400 - 9mm spr.	.5	8.77	4.39
TAX			46.66
Labor:			
Drywall - 100 M @ .86			86.00
Frame - 100 M @ 4.30			430.00
Chimney Box			5.00
			2,167.68

TUMBLER RIDGE, BRITISH COLUMBIA

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MATERIAL & LABOR

CONSTRUCTION: RETRO-FIT READY DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
BASEMENT - Material:			
40 M 38 x 140 - Mud Sill	131	281	36.81
40 M 28 x 28 spr. (inside basement)	44	319	14.04
37 1200 x 2400 - 38mm S.M. (includes header)	1184	440	520.96
18 pieces 685 mm x 2400 mm metal lathe	18	4.78	86.04
TAX			32.89
- Labor:			
Insulation - 96 M^2 @ 1.10			105.60
Metal Lathe - 26 M^2 @ 1.72			44.72
Extra Cost Parging - 26 M^2 @ 3.60			93.60
			934.66
Costs per M^2 = Ceiling (99.84) $ 21.71			
Walls (96) $ 23.87			
Basement (96) $ 9.74			
Assumptions:			
concrete contractor charges the same price for			
beam fill and mud sill joist construction.			

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: RETRO-FIT READY

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
CEILING - Material			
1 roll 6 M x 1500 poly	1.5	31.39	47.09
Caulking	2	5.45	10.90
Insulation Baffles	34	.25	8.50
TAX			2.90
- Labor:			
Poly - 100 M^2 @ .70			70.00
Caulking - 100 M^2 @ .70			70.00
Plumbing, hole finding			66.00
			266.89
WALLS - Material:			
2 rolls 6 M x 1000 poly (incl. header)	2	31.39	62.78
Caulking	6	5.45	32.70
TAX			4.77
- Labor:			
Poly - 96 M^2 @ .70			67.20
Caulking - 96 M^2 @ .70			67.20
Header Poly & Window Poly - Hole Finding			180.00
			414.65
BASEMENT - Material: N/A			
SLAB - Material: 1 roll 6 M x 1500 poly	1.5	31.39	47.09
TAX			2.35
- Labor: Lay Poly 96 M^2 @ .52			50.00
			99.44
TOTAL			780.98

VAPOR BARRIER (cont'd) CONSTRUCTION: RETRO-FIT READY

DETACHED BUNGALOW

		AMOUNT	PRICE	EXTENSION
Cost per M^2 = Ceiling (99.84)	$ 2.67			
Walls (96)	$ 4.32			
Basement (96)	O.S. insulation			
Slab (93)	$ 1.07			

DOORS & WINDOWS CONSTRUCTION: RETRO-FIT READY

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
DOORS: 2 s.c. wood doors	2	182.00	364.00
8 7/8 jamb	2	35.00	70.00
better weatherstrip	2	22.00 (extra)	44.00
storm door #120	2	87.98	175.96
			653.96
			32.70
			686.66
Labor: hang storm door	2	12.00	24.00
			710.66
WINDOWS - 4 3/8 jamb extended to 8 7/8			
- wood			
- triple glazed on non south			
Bedrooms - 2 (south) (185.22)	2	185.22	371.44
1 (north)	1		224.91
Kitchen - 1 (north)	1		126.46
Bath - 1 (north)	1		180.14
Liv. Rm. - 1 (south)	1		298.68
			1,201.63
			60.08
			1,261.71
Material for Jambs: 25.6 M 19 x 140 clear fir	84	95.65	80.35
TAX			4.02
Labor: 6 windows @ 10.00 ea. - Trim			60.00
6 windows @ 3.00 ea. - Paint			18.00
			1,424.08

TUMBLER RIDGE, BRITISH COLUMBIA

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VENTILATION

CONSTRUCTION: RETRO-FIT READY

DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Directing Ductword Down - (Elec.) Bath			28.65
Kitchen			28.65
Kitchen Fan			54.00
(Mech.) Box & Exhaust			50.00
Misc.			40.00
			201.30
Assume: other units do not have range hood but do			
have bath fan.			

TUMBLER RIDGE, BRITISH COLUMBIA

MATERIAL & LABOR

CONSTRUCTION: RETRO-FIT READY PLUS DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
WALLS - Material:			
120 M - 38 x 140 spr. plates	394	281	110.71
120 - 38 x 140 spr. studs	960	274	263.04
33 - 1200 x 2400 - 38mm S.M.	1050	440	464.64
200M - 38 x 64 Spr.	328	274	89.87
33 - 1200 x 2400 - 12mm Drywall	1056	207.05	218.64
TAX			57.35
Labor:			
Drywall - 96 M^2 @ .86			82.56
RSI 3.5 insulation O.S. - 86.4 @ 3.71			320.54
RSI 1.4 insulation I.S. - 86.4 @ 1.94			167.62
Frame O.S. - 100 M^2 @ 6.46			646.00
I.S. - 100 M^2 @ 1.08			108.00
			2,528.97
Cost per M^2 = Wall (96M^2) $ 26.34			

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
17 38 x 89 - 10.0 trusses cantilevered .600 each end	17	58.72	998.24
RSI 10.6 blown insulation	108M^2	9.90	1,069.20
Cardboard eave baffles 34 x .25			8.50
34 - 1200 x 2400 - 15 mm Drywall	1088	268.39	288.25
(roof sht.) (chimney box) 3.5 - 1200 x 2400 - 9 mm spr.	3.5	8.77	30.70
TAX			66.28
- Labor:			
Frame 108 M @ 4.30			464.40
Chimney Box			5.00
Drywall 100 M^2 @ .86			86.00
			3,016.57
WALLS - Material:			
80 - 38 x 89 spr. plates	175	260	46.90
80 - 38 x 89 spr. studs	427	255	108.89
33 - 1200 x 2400 - 9 mm spr. sht.	33	8.77	289.41
22 M - 38 x 89 header blocking	48	268	12.86
80 - 38 x 64 spr. plates	131	274	35.89
88 - 38 x 64 spr. studs	352	274	96.45
9 - 1200 x 2400 - 12 mm spr. (plate)	9	12.15	109.35
35 - 1200 x 2400 - 12 mm drywall	1120	207.05	231.90
43 - 89 M x 90 colorlok	144	9.00	129.60
42 M - 38 x 184 spr. mud sill	184	287	52.81
TAX			55.70
- Labor:			
Drywall - extra trip			30.00
Drywall - 96 M^2 @ .86			82.56
Header insulation O.S. - 10.5 M @ 3.71			38.96
Insulation - 86.4 M @ 3.71			320.54
Header insulation I.S. - 10.5 M @ 1.94			20.37
Insulation O.S. - 86.4 @ 1.94			167.62
Insulation I.S. - 86.4 @ 2.53 M^2			218.59
Install Header Blocking			40.00

	AMOUNT	PRICE	EXTENSION
WALLS - Labor: (cont'd)			
Frame O.S. - 108 M^2 @ 8.61			929.88
Siding - 13.38 M^2 @ 3.77 per M^2			50.44
			3,068.72
BASEMENT - Material:			
19 pcs. 615 mm x 2400 metal lathe	19	4.78	90.82
35 - 1200 x 2400 - 38 mm S.M.	1120	440	492.80
80 M 38 x 64 spr. plates	132	274	36.17
80 - 38 x 64 spr. studs	320	274	87.68
34 - 1200 x 2400 - 12 mm Drywall	1088	207.05	225.27
42 M - 38 x 64 Concrete Nailer	69	274	18.91
TAX			50.59
- Labor:			
Frame - 40 M @ 2.30			92.00
RSI 2.1 (int.) Insulation 96 M^2 @ 2.53			242.88
RSI 1.4 (hor) Insulation96 M^2 @ 1.94			186.24
38 mm S.M. Ext. Insulation 96 M^2 @ 1.10			105.60
Metal Lathe - 28 M^2 @ 1.72			48.16
Extra Cost Parging			120.00
Int. Tar - 66 M^2 @ 1.61			106.26
			1,903.38
SLAB - 25 mm S.M. - Material:			
25 mm Sand - 3 M^3 @ 20.00 ea.			60.00
33 - 1200 x 2400 25 mm S.M.	1023	313	320.20
TAX			17.51
- Labor:			
to spread sand & lay S.M.			120.00
			517.71
Assume: sand dumped through window and wheelbarrowed			
into place with protection for poly.			

MATERIAL & LABOR CONSTRUCTION: SUPER ENERGY EFFICIENT DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
SLAB - 50 mm S.M. - Material:			
25 mm Sand - 3 M^2 @ 20.00 ea.			60.00
33 - 1200 x 2400 - 50 mm S.M.	1023	626	640,40
TAX			33.52
- Labor:			
to spread sand & lay S.M.			120.00
			853.92
Cost per M^2 = Ceiling (99.84) $ 30.21			
Walls (96) $ 31.97			
Basement (96) $ 19.83			
Slab - 25 mm (93) $ 5.57			
Slab - 50 mm (93) $ 9.18			

VAPOR BARRIER CONSTRUCTION: SUPER ENERGY EFFICIENT DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
1 roll 6M x 1500 poly	1.5	31.39	47.09
caulking	2	5.45	10.90
TAX			2.90
- Labor:			
poly 100 M^2 @ .70			70.00
caulking 100 M^2 @ .70			70.00
Repairs, Hole finding, Plumbing Stacks			150.00
			350.00
WALLS - Material:			
2 rolls 6 M x 1000 poly	2	31.39	62.78
caulking	6	5.45	32.70
TAX			4.77
- Labor:			
Caulk 96 M^2 @ .70			67.20
Poly 96 M^2 @ .70			67.20
Building Paper			6.00
Header & Window Poly			80.00
Repairs, Hole Finding, Etc.			150.00
			464.65
BASEMENT - Material:			
1 roll 6M x 1000 poly	1	31.39	31.39
4 tubes caulking	4	5.45	21.80
TAX			2.66
- Labor:			
Poly 96 M^2 @ .70			67.20
Repairs, Electrical, Etc.			50.00
Caulking 96 M^2 @ .70			67.20
			240.25
Assume: no plugs inside basement walls.			

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: SUPER ENERGY EFFICIENT DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
SLAB - Material:			
1 roll 6 M x 1500 poly	1.5	31.39	47.09
TAX			2.35
- Labor:			
93 M^2 @ .43			40.00
			89.44
Assume: installers have had proper training.			
TOTAL			1,144.34
Poly costs per M^2 = Ceiling (99.84) $ 3.51			
Walls (96) $ 4.84			
Basement (96) $ 2.50			
Slab (93) $ .96			

TUMBLER RIDGE, BRITISH COLUMBIA

DOORS & WINDOWS

CONSTRUCTION: SUPER ENERGY EFFICIENT DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
DOORS - 2 s.c. wood doors	2	182.00	364.00
300 jamb (12)	2	40.00	80.00
better weatherstrip	2	22.00 diff.	44.00
storm d-or #120	2	87.98	175.96
			663.96
			33.20
			697.16
- Labor - hang storm door	2	12.00	24.00
			721.16
WINDOWS - 4 3/8 jamb built out to 12			
wood			
triple glazed			
Bedroom - 3 2W2	2	224.91	674.73
Bath - 1 2924	1	126.46	126.46
Kitchen - 1 4130	1	180.17	180.17
Liv. Rm. - 1 30 x 30 x 30/60	1	385.14	385.14
			1,366.50
TAX			68.33
			1,434.83
Material for jambs - 3 - 1200 x 2400 - 15mm GIS fir	3	22.29	66.87
			3.34
Labor - Trim 6 windows @ 12.00			72.00
- Paint 6 windows @ 5.00			30.00
			1,607.04

TUMBLER RIDGE, BRITISH COLUMBIA

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VENTILATION & HEAT RECOVERY

CONSTRUCTION: SUPER ENERGY EFFICIENT DETACHED BUNGALOW

		AMOUNT	PRICE	EXTENSION
(Mech.)	air to air (inst. not wired)			1,400.00
(Elec.)	Wire Fans			49.00
	Bath Fan Overide (labor done @ time of Rough-in)			10.00
	Humidistat Wiring			12.00
	Dryer Relay			22.00
				1,493.00

TUMBLER RIDGE, BRITISH COLUMBIA

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VAPOR BARRIER

CONSTRUCTION: STANDARD
SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9.6 x 10.0 = 96 M^2			
Building size to be 20 x 9.6			
CEILING - 96 M^2 @ .26			24.96
WALLS - 71 M^2 @ .27			19.17
BASEMENT - 71 M^2 @ .13			9.23
			53.36

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: MEASURES

SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9.6 x 10.0			
Building size to be 20 x 9.6			
CEILING - 96 M^2 @ .26			24.96
WALLS - 71 M^2 @ .58			41.18
BASEMENT - 71 M^2 @ .27			19.17
			85.31

VAPOR BARRIER CONSTRUCTION: RETRO-FIT READY
SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9.6 x 10.0			
Building size to be 20 x 9.6			
CEILING - 96 M^2 x 2.67			256.32
WALLS - 71 M^2 @ 4.32			306.72
BASEMENT - 71 M^2 @			
SLAB - 89.2 M^2 @ 1.07			95.44
			658.48

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: SUPER ENERGY EFFICIENT SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9.6 x 10.0			
Building size to be 20 x 9.6			
CEILING - 96 M^2 @ 3.51			336.96
WALLS - 71 M^2 @ 4.84			343.64
BASEMENT - 71 M^2 @ 2.50			177.50
SLAB - 89.2 M^2 @ .96			85.63
			943.73

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: STANDARD
SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9 x 8.4 = 75.6 M^2			
Building size to be 9 x 16.8			
CEILING - 75.6 M^2 @ .26			19.66
WALLS - 62 M^2 @ .27			16.74
BASEMENT - 62 M^2 @ .13			8.06
			44.46

VAPOR BARRIER CONSTRUCTION: MEASURES

SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9 x 8.4			
Building size to be 9 x 16.8			
CEILING - 75.6 M^2 @ .26			19.66
WALLS - 62 M^2 @ .58			35.96
BASEMENT - 62 M^2 @ .27			16.74
			72.36

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: RETRO-FIT READY
SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9 x 8.4			
Building size to be 9 x 16.8			
CEILING - 75.6 M^2 @ 2.67			164.05
WALLS - 62 M^2 @ 4.32			203.36
BASEMENT - 62 M^2			
SLAB - 67.9 M^2 @ 1.07			72.65
			440.06

VAPOR BARRIER CONSTRUCTION: SUPER ENERGY EFFICIENT SEMI-DETACHED BUNGALOW

	AMOUNT	PRICE	EXTENSION
Unit size to be 9 x 8.4			
Building size to be 9 x 16.8			
CEILING - 75.6 M^2 @ 3.51			265.36
WALLS - 62 M^2 @ 4.84			300.08
BASEMENT - 62 M^2 @ 2.50			155.00
SLAB - 67.9 M^2 @ .96			65.18
			785.62

MATERIAL & LABOR CONSTRUCTION: STANDARD
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
60 - 38 x 89 - 9.0 trusses std. heel	60	29.96	1,797.60
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
TAX			127.31
- Labor:			
324 M^2 RSI 3.5 blown insulation	324	3.71	1,202.04
Frame - 324 M^2 @ 4.30			1,393.20
Drywall - 324 M^2 @ .86			278.64
			5,495.64
Assume: wall to begin at top of concrete.			
WALLS - Material:			
.540 M - 38 x 89 plates	1182	268	316.78
209 - 38 x 89 - 2.4 M studs	1115	255	284.33
209 - 38 x 89 - 1.2 M studs	558	255	142.29
113 - 1200 x 2400 - 9 mm spr.	113	8.77	991.01
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
TAX			124.16
- Labor:			
Insulation - 324 M^2 RSI 2.1 insulation	324	2.53	819.72
Frame - 324 M^2 @ 6.46			2,093.04
Frame, pony wall - 90 M @ 3.25 per M			292.50
Drywall - 324 M^2 @ .86			278.64
			6,091.16
BASEMENT - Material:			
179.2 M - 38 x 89 plates	392	268	105.06
209 - 38 x 89 - 1.2 M studs	1115	255	284.33
38 - 1200 x 2400 - 12 mm drywall	1216	207.05	251.77
TAX			32.06
- Labor:			
Frame - 89.6 M @ 1.64			146.94
107.5 M^2 RSI 2.1 insulation	107.5	2.53	271.98
Drywall - 108 M^2 @ .86			92.88
Tar - 89.6 M @ 1.61			144.26
			1,329.28

MATERIAL & LABOR CONSTRUCTION: STANDARD
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
Assume: all units to be equal in component area.			
Standard Cost per M^2 - Ceiling (54 M^2) = $ 17.12			
- Walls (54.9) = $ 18.49			
- Basement (18) = $ 12.31			

VAPOR BARRIER CONSTRUCTION: STANDARD
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
3 rolls - 2 M x 1500 poly	3	14.28	42.84
TAX			2.14
- Labor:			
324 M^2 @ .11			35.64
			80.62
WALLS - Material:			
3 rolls - 2 M x 1500 poly	3	14.28	42.84
TAX			2.14
- Labor:			
324 M^2 @ .11			35.64
			80.62
BASEMENT - Material:			
1 roll - 2 M x 1500 poly	1	14.28	14.28
TAX			.71
- Labor:			
108 M^2 @ .11			11.88
			26.87
Standard Poly costs per M^2:			
Ceiling (54) = $ .25			
Walls (54.9) = $ .24			
Basement (18) = $ .18			

DOORS & WINDOWS

CONSTRUCTION: ALL CONSTRUCTION TYPES
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
Assume: Doors & Windows to be the same as Bungalow.			

MATERIAL & LABOR - METHOD (a)

CONSTRUCTION: MEASURES
ROW HOUSE BI - LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
60 - 38 x 89 trusses (57 mm heel) - 9.0 M	60	31.35	1,881.00
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
TAX			131.48
- Labor:			
Frame - 324 M^2 @ 4.30			1,393.20
Insulation - 324 M^2 @ 5.60 RSI 5.6			1,814.40
Drywall - 324 M^2 @ .86			278.64
			6,247.41
WALLS - Material:			
540 - 38 x 140 plates	1772	281	497.93
209 - 38 x 140 - 2.4 M studs	1672	274	458.13
209 - 38 x 140 1.2 M studs	836	274	229.06
113 - 1200 x 2400 - 9 mm spr.	113	8.77	991.01
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
TAX			146.24
- Labor:			
Frame - 324 M^2 @ 6.46			2,093.04
Frame, pony wall - 90 M @ 3.25			292.50
Insulation RSI 3.5 - 324 M^2 @ 3.71			1,202.04
Header insulation RSI 3.5 - 27 M @ 3.71			100.17
Drywall - 324 M^2 @ .86			278.64
			7,037.45
BASEMENT - Material: same as standard.			
Measures Method (a) Cost per M^2:			
Ceiling (54 M^2) = $ 19.28			
Walls (54.9 M^2) = $ 21.36			
Basement (18) = $ 12.31			

MATERIAL & LABOR - METHOD (b) CONSTRUCTION: MEASURES
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
WALLS - Material:			
540 - 38 x 89 plates	1182	268	316.73
290 - 38 x 89 - 2.4 M studs	1547	255	394.49
290 - 38 x 89 - 1.2 M studs	774	255	189.72
116 - 1200 x 2400 - 38 mm S.M. Incl. Header	3712	440	1,633.23
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
TAX			164.15
- Labor:			
Frame - 324 M^2 @ 6.46			2,093.04
Frame, pony wall - 90 M @ 3.25			292.50
Insulation RSI 2.1 - 251 M^2 @ 2.53 - Incl. Header Insul.			888.03
Drywall - 324 M^2 @ .86			278.64
			6,999.32
Measures Method (b) Cost per M^2:			
Walls (54.9 M^2) = $ 21.25			

VAPOR BARRIER CONSTRUCTION: MEASURES

ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material: same as Standard			
WALLS - Material:			
3 rolls - 2 M x 1500 poly	3	14.28	42.84
TAX			2.14
- Labor:			
324 M^2 @ .11			35.64
Header Poly			50.00
			130.62
BASEMENT - Material: same as standard			
Measures Poly cost per M^2:			
Walls (54.9) = $ .40			

MATERIAL & LABOR

CONSTRUCTION: RETRO-FIT READY
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
3 - 1200 x 2400 - 9 mm spr. (chimney box)	3	8.77	26.31
60 - 38 x 89 - 9 M trusses (89 mm heel)	60	33.35	2,001.00
120 - insulation baffles @ .25	120	.25	30.00
113 - 1200 x 2400 - 15 mm drywall	3616	268.39	970.50
TAX			151.39
- Labor:			
324 M^2 RSI 7.1 blown insulation	324	6.62	2,144.88
Frame - 324 M^2 @ 4.30			1,393.20
Drywall - 324 M^2 @ .86			278.64
Frame, chimney box - 6 @ 5.00			30.00
			7,025.92
WALLS - Material:			
540 - 38 x 140 plates	1772	281	497.92
209 - 38 x 140 - 2.4 M studs	1672	274	458.13
209 - 38 x 140 - 1.2 M studs	836	274	229.06
450 M - 38 x 64 spr.	738	274	202.21
113 - 1200 x 2400 - 9 mm spr.	113	8.77	991.01
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
10 - 1200 x 2400 - 38 S.M.	320	440	140.80
TAX			163.39
- Labor:			
Frame O.S. - 324 M^2 @ 6.46			2,093.04
I.S. - 324 M^2 @ 1.08			349.92
Insulation O.S. - 324 M^2 RSI 3.5	324	3.71	1,202.04
I.S. - 324 M^2 RSI 1.4	324	1.94	618.84
Drywall - 324 M^2 @ .86			278.64
Rigid - 27 M^2 @ 1.10			29.70
			7,973.69

MATERIAL & LABOR

CONSTRUCTION: RETRO-FIT READY
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
BASEMENT - Material:			
38 - 1200 x 2400 - 38 mm S.M.	1216	440	535.04
Metal Lathe - 19 - 685 x 2400	19	4.78	90.82
179.2 M - 38 x 89 plates	392	2.68	105.06
209 - 38 x 89 1.2 M studs	1115	255	284.33
38 - 1200 x 2400 - 12 mm drywall	1216	207.05	251.77
TAX			63.35
- Labor:			147.60
Frame - 90 M @ 1.64	108	3.71	400.65
Insulation - 108 M^2 RSI 3.5			144.90
Tar - 90 M^2 @ 1.61			77.40
Drywall - 90 M^2 @ .86			118.80
Install Rigid - 108 @ 1.10			30.00
Cut lathe			53.32
Install lathe - 31 M^2 @ 1.72			97.20
Parging - 27 @ 3.60			2,400.24
Retro-Fit Ready Costs per M^2:			
Ceiling (54 M^2) = $ 21.68			
Walls (54.9 M^2) = $ 24.21			
Basement (18) = $ 22.22			

MATERIAL & LABOR CONSTRUCTION: RETRO-FIT READY PLUS ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - same as Retro Fit Ready			
WALLS - Material:			
540 - 38 x 140 spr. plates	1772	281	497.92
290 - 38 x 140 spr. studs 2.4 M	2320	274	635.68
290 - 38 x 140 spr. studs 1.2 M	1160	274	317.84
116 - 1200 x 2400 - 38 mm S.M. (incl. header)	3712	440	1,633.28
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.69
8 - 38 x 3.0 M metal braces	80	.10	8.00
TAX			192.07
- Labor:			
Frame - O.S. - 324 M^2 @ 6.46			2,093.04
- I.S. - 324 M^2 @ 1.08			349.92
Insulation - O.S.- 324 M^2 @ RSI 3.5	324	3.71	1,202.04
- I.S.- 324 M^2 @ RSI 1.4	324	1.94	618.84
Drywall - 324 M^2 @ .86			278.64
			8,575.96
Retro-Fit Ready Plus costs per M^2:		✓	
Walls - (54.9) = $ 26.04			

VAPOR BARRIER CONSTRUCTION: RETRO-FIT READY
ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
4.5 rolls - 6 M x 1000 poly	4.5	31.39	141.26
Caulking - 8 tubes	8	5.45	43.60
TAX			9.24
- Labor:			
324 M^2 @ .70			226.80
Caulk 324 M^2 @ .70			226.80
Stacks & Hole finding			150.00
			797.70
WALLS - Material:			
4.5 Rolls - 6 m x 1000 poly	4.5	31.39	141.26
Caulking	28	5.45	152.60
TAX			14.69
- Labor:			
Poly - 324 M^2 @ .70			226.80
Caulking - 324 M^2 @ .70			226.80
Stacks & hole finding, header & Window poly			660.00
			1,407.46
BASEMENT - Material:			
2 rolls - 6 M x 1000 poly	2	31.39	62.78
Caulking	16	5.45	87.20
Poly pans	24	1.00	24.00
TAX			8.70
- Labor:			
Poly - 108 M^2 @ .70			75.60
Caulk 108M^2 @ .70			75.60
Hole finding & poly pans			240.00
			573.88
SLAB - same as bungalow			
Assume: basement poly begins at top of concrete.			
Retro-Fit poly costs per M^2: Ceiling (54) = $ 2.46			
Walls (54.9) = $ 4.27			
Basement (18) = $ 5.31			

MATERIAL & LABOR CONSTRUCTION: SUPER ENERGY EFFICIENT ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
61 - 38x89 - 10.2M trusses cantilevered .600 ea. end	61	47.03	2,868.83
122 Cardboard baffles	122	.25	30.50
113 - 1200 x 2400 - 15 mm drywall	3616	268.39	970.50
TAX			193.49
- Labor: Frame - 342 M^2 @ 4.30			1,470.60
Insulation - 342. M^2 @ RSI 10.6	342	9.90	3,385.80
Drywall - 324 M^2 @ .86	324	.86	278.64
Chimney box - 6 @ 5.00	6	5.00	30.00
			9,228.36
WALLS - Material:			
180 M - 38 x 89 spr. plates	394	268	105.59
180 M - 38 x 140 spr. plates	591	281	166.07
209 - 38 x 89 - 2.4 M spr. studs	1115	255	284.33
209 - 28 x 140 - 1.2 M spr. studs	836	274	229.06
360 - 38 x 64 spr. plates	590	274	161.66
209 - 38 x 64 - 2.4 M spr. studs	836	274	229.06
209 - 38 x 64 - 1.2 M spr. studs	418	274	114.53
38 - 1200 x 2400 - 12 mm spr. plumbing plates	38	12.15	461.70
63.7 M - 38 x 89 spr. block	139	268	32.25
113 - 1200 x 2400 - 9 mm Spr.	113	877	991.01
113 - 1200 x 2400 - 12 mm drywall	3616	207.05	748.60
90 x X90 colorcox	295	900	265.50
TAX			176.19
- Labor: Frame - 342 M^2 @ 8.61			2,944.62
Insulation - O.S. - 324 M^2 @ 1.94 (RSI 1.4)			628.56
- 324 M^2 @ 3.71 (RSI 3.5)			1,202.04
- I.S. - 324 M^2 @ 2.53 (RSI 2.1)			819.72
Header Insulation O.S.- 27 M^2 @ 3.71 (RSI 3.5)			94.50
I.S.- 27 M^2 @ 2.53 (RSI 2.1)			68.31
Install Header Block			100.00
Install siding - 27 M^2 @ 3.77			101.79
Drywall extra trip			30.00
			9,955.09
BASEMENT - Material: same as Retro-Fit Ready			

VAPOR BARRIER CONSTRUCTION: SUPER ENERGY EFFICIENT ROW HOUSE BI-LEVEL

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
4.5 rolls - 6 M x 1000 poly	4.5	31.39	141.26
Caulking	8	5.45	43.60
TAX			9.24
- Labor:			
Poly 342 M^2 @ .70			239.40
Caulk 342 M^2 @ .70			239.40
Stacks & hole finding			300.00
			972.90
WALLS - Material:			
4.5 rolls - 6 M x 1000 poly	4.5	31.39	141.26
Caulking	28	5.45	152.60
TAX			14.69
- Labor:			
Poly - 324 M^2 @ .70			226.80
Caulk - 324 M^2 @ .70			226.80
Window & Header poly			300.00
Hole finding			480.00
			1,742.15
Assume: basement begins at top of concrete.			
BASEMENT - Material:			
2 rolls - 6 M x 1000 poly	2	31.39	62.78
Caulking	16	5.45	87.20.
Poly pans	24	1.00	24.00
TAX			8.70
- Labor: Poly - 108 M^2 @ .70			75.60
Caulk - 108 M^2 @ .70			75.60
Hole finding & poly pans			400.00
			733.88
SLAB - same as bungalow			
Super E.E. Poly costs per M^2: Ceiling (54) = $ 3.00			
Walls (84.9) = $ 5.38			
Basement (18) = $ 6.80			

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
39 - 38 x 89 - 9.6 M Trusses std. heel	39	36.77	1,434.03
230.4 M^2 RSI 3.5 insulation	230.4 M^2	3.55	817.92
80 - 1200 x 2400 - 12 mm drywall	2560	207.05	530.05
TAX			98.20
- Labor:			
Frame - 230.4 M^2 @ 4.30 per M^2			990.72
Drywall - 230.4 M^2 @ .86 per M^2			198.14
			4,069.06
WALLS - Material:			
403.2 M - 38 x 89 spr. plates	882	268	236.38
374 - 38 x 89 - 2.4 M spr. studs	1996	255	503.98
112 - 1200 x 2400 - 9 mm spr. sht.	112	8.77	982.24
112 - 1200 x 2400 - 12 mm drywall	35.84	207.05	742.07
TAX			123.48
- Labor:			
Insulation - 322.5 M^2 RSI 2.1 @ 2.53 per M^2			815.93
Frame - 460.8 M^2 @ 6.46 per M^2			2,976.77
Drywall - 322.5 M^2 drywall @ .86 per M^2			277.35
			6,663.20
BASEMENT - Material			
28 - 600 x 2400 - 38 mm S.M.	448	.440	197.12
14 - 1200 x 2400 - 12 mm drywall	448	207.05	92.76
TAX			14.49
- Labor:			
Insulation - 40.3 M^2 @ 1.10			44.33
Drywall - 40.3 M^2 @ .86 per M^2			34.66
			283.36
Assume: all units to be equal in component area.			

	AMOUNT	PRICE	EXTENSION
Ceiling area (i) - 230.4 M^2 ÷ 12 = 19.20 M^2 ea.			
for cost per M^2 divide total cost by unit number and			
ceiling area.			
Wall area (i) - 460.8 M^2 ÷ 12 = 38.4 M^2 ea.			
(ii) -			
Basement area (i) - 40.3 M^2 ÷ 12 = 3.36 M^2 ea.			
Standard - Ceiling cost per M^2 (19.2) = $ 17.66			
- Wall cost per M^2 (38.4) = $ 14.46			
- Basement cost per M^2 (3.36) = $ 9.51			

VAPOR BARRIER CONSTRUCTION: STANDARD APARTMENT

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
2 rolls - 2M x 1500 poly	2	14.28	28.56
TAX			1.32
- Labor:			
230.2 M^2 @ .11			25.32
			55.20
WALLS - Material:			
2.5 rolls - 2 M x 1500 poly	2.5	14.28	35.70
TAX			1.79
- Labor: 322.5 M^2 @ .11			35.48
			72.97
GRADE BEAM - N/A			
CRAWL SPACE FLOOR - 2 rolls - 2M x 1500 poly			28.56
TAX			1.32
- Labor: 232.2 M^2 @ .11			25.32
			55.20
Poly costs per M^2 - Ceiling (19.2) = $ .24			
- Walls (38.4) = $ .16			
- Foundation = N/A			
- Crawl Space Floor = $ .23			

TUMBLER RIDGE, BRITISH COLUMBIA

DOORS & WINDOWS

CONSTRUCTION: STANDARD APARTMENT

	AMOUNT	PRICE	EXTENSION
DOORS - 1 s.c. wood door	1	182	182.00
TAX			9.10
			191.10
WINDOWS - Bedroom - 1 2W2	1	185.72	185.72
- Bath - 1 2924	1	107.83	107.83
- Liv. Rm. - 1 30 x 30 x 30/60 S.V.	1	298.68	298.68
			592.23
TAX			29.61
			621.84

MATERIAL & LABOR - METHOD (a) CONSTRUCTION: MEASURES APARTMENT

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
39 - 38 x 89 - 9.6 trusses (57 mm heel)	39	38.27	1,492.53
230.4 M^2 RSI 5.6 blown insulation	230.4M^2	5.60	1,290.24
80 - 1200 x 2400 - 12 mm drywall	2560	207.05	530.05
TAX			101.13
- Labor:			
Frame - 230.4 M^2 @ 4.30 per M^2			990.72
Drywall - 230.4 M^2 @ .86			198.14
			4,602.81
WALLS - Material:			
403.2 M - 38 x 140 spr. plates	1323	281	371.76
374 - 38 x 140 - 2.4 M spr. studs	2992	274	819.81
112 - 1200 x 2400 - 9 mm spr. sht.	112	8.77	982.24
112 - 1200 x 2400 - 12 mm drywall	3584	207.05	742.07
TAX			145.79
- Labor:			
Insulation - 322.5 M^2 RSI 3.5 @ 3.71			1,196.48
Header insulation - 40 M^2 RSI 2.1 @ 2.53			101.20
Frame - 460.8 M^2 @ 6.46 per M^2			2,976.77
Drywall - 322.5 M^2 @ .86 per M^2			277.35
			7,613.47
BASEMENT - Material: same as standard			
Measures Method (a) -			
Ceiling cost per M^2 (19.2) = $ 19.98			
Wall cost per M^2 (38.4) = $ 16.52			
Basement cost per M^2 (3.36) = $ 9.51 (same as standard)			

MATERIAL & LABOR - METHOD (b) CONSTRUCTION: MEASURES APARTMENT

	AMOUNT	PRICE	EXTENSION
WALLS - Material:			
403.2 M - 38 x 89 spr. plates	882	268	236.38
484 - 38 x 89 spr. studs	2583	255	658.67
118 - 1200 x 2400 - 38 mm S.M. (incl. 2nd floor header)	3776	440	1,661.44
112 - 1200 x 2400 - 12 mm drywall	3584	207.05	742.07
16 - 38 mm x 3050 mm metal braces	160	.10	16.00
TAX			164.93
- Labor:			
Insulation - 322.5 M^2 RSI 2.1 @ 2.53			815.93
Header insulation - 40 M^2 RSI 2.1 @ 2.53			101.20
Frame - 460.8 M^2 @ 6.46 per M^2			2,976.77
Drywall - 322.5 M^2 @ .86 per M^2			277.35
			7,650.74
Measures Method (b) - Wall cost per M^2 (38.4) = $ 16.60			

TUMBLER RIDGE, BRITISH COLUMBIA

VAPOR BARRIER

CONSTRUCTION: MEASURES

APARTMENT

	AMOUNT	PRICE	EXTENSION
CEILING - same as standard			
WALLS - Material:			
3 rolls 2 M x 1500 poly	3	14.28	42.84
TAX			2.14
- Labor:			
Header poly (2 rows)			80.00
Poly Labor - 322.5 M^2 @ .11			35.48
			160.46
FOUNDATION - N/A			
CRAWL SPACE - same as standard			
Assume: wall area to be to top of concrete.			
Measures poly costs per M^2 = Ceiling (19.2) = $ .24			
Walls (38.4) = $ .35			
Foundation = N/A			
Crawl Space (20.33) = $.23			

TUMBLER RIDGE, BRITISH COLUMBIA

DOORS & WINDOWS

CONSTRUCTION: MEASURES

APARTMENT

	AMOUNT	PRICE	EXTENSION
DOORS - 1 s.c. wood door	1	182	182.00
extended jamb			20.00
			202.00
TAX			10.10
			212.10
WINDOWS - Standard			592.23
- extended jamb			82.00
			674.23
			33.71
			707.94

MATERIAL & LABOR CONSTRUCTION: RETRO-FIT READY APARTMENT

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
39 - 38 x 89 - 9.6 M trusses (89 mm heel)	39	40.27	1,570.53
230.4 M^2 RSI 7.1 blown insulation	230.4	6.62	1,525.25
80 - 1200 x 2400 - 15 mm drywall	2560	268.39	687.03
78 insulation baffles	78	.25	19.50
Chimney Box - 5 - 1200 x 2400 - 9 mm spr.	5	8.77	43.85
TAX			116.06
- Labor:			
Frame - 230.4 M^2 @ 4.30 per M^2			990.72
Drywall - 230.4 M^2 @ .86 per M^2			198.14
Chimney Box frame - 6 @ 5.00 ea.			30.00
			5,181.12
WALLS - Material:			
403.2 M - 38 x 140 spr. plates	1323	281	371.76
374 - 38 x 140 spr. studs	2992	274	119.82
112 - 1200 x 2400 - 9 mm spr.	112	8.77	982.24
112 - 1200 x 2400 - 12 mm drywall	3584	207.05	742.07
672 M - 38 x 64 spr.	1102	274	301.95
TAX			125.89
- Labor:			
Frame O.S. - 460.8 M^2 @ 6.46			2,976.77
I.S. - 460.8 M^2 @ 1.08			497.66
RSI 3.5 Insulation O.S. - 460.8 M^2 @ 3.71			1,196.48
RSI 1.4 horizontal I.S. - 460.8 M^2 @ 1.94			893.95
Drywall - 322.5 M^2 @ .86 per M^2			277.35
			8,485.93
BASEMENT - Material:			
28 - 600 x 2400 - 38 mm S.M.	448	440	197.12
28 - 685 x 2400 - metal lathe	28	4.78	133.84
TAX			16.55
- Labor: Insulation - 40.3 @ 1.10			44.33
Metal Lathe - 40.3 @ 1.72			69.32
Parging - 40.3 @ 3.60			145.08
			606.24

MATERIAL & LABOR CONSTRUCTION: RETRO-FIT READY APARTMENT

	AMOUNT	PRICE	EXTENSION
Retro-Fit Ready Cost per M^2 -			
Ceiling (19.2) = $ 22.49			
Walls (38.4) = $ 18.42			
Basement (3.36) = $ 15.04			
Assume: no header insulation because of vapor barrier			
positioning.			

MATERIAL & LABOR CONSTRUCTION: RETRO-FIT READY PLUS APARTMENT

	AMOUNT	PRICE	EXTENSION
WALLS - Material:			
403.2 M - 38 x 140 spr. plates	1323	281	371.76
484 - 38 x 140 spr. studs	1588	274	435.11
118 - 1200 x 2400 - 38 mm S.M. (incl. 2nd floor header)	3776	440	1,661.44
112 - 1200 x 2400 - 12 mm drywall	3584	207.05	742.07
672 M - 38 x 64 spr.	1102	274	301.95
TAX			175.62
- Labor:			
Frame O.S. - 460.8 M^2 @ 6.46			2,976.77
I.S. - 460.8 M^2 @ 1.08			497.66
RSI 3.5 insulation O.S. - 460.8 M^2 @ 3.71			1,196.48
RSI 1.4 horizontal I.S. - 460.8 M^2 @ 1.94			893.95
Drywall - 322.5 M^2 @ .86			277.35
			9,530.16
Retro-Fit Ready Plus -			
Walls cost per M^2 (38.4) = $ 20.68			

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VAPOR BARRIER CONSTRUCTION: RETRO-FIT READY APARTMENT

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
2 rolls - 2 M x 1500 poly	3	31.39	94.17
Caulking - 6 tubes	6	5.45	32.70
TAX			6.34
- Labor:			
Poly - 230.2 M^2 @ .70			161.14
Caulking - 230.2 M^2 @ .70			161.14
Stacks, hole finding			150.00
			605.49
WALLS - Material:			
3 rolls - 6 M x 1500 poly	4.5	31.39	141.26
Caulking	24	5.45	130.80
TAX			13.60
- Labor:			
Poly - 322.5 M^2 @ .70			225.75
Caulking - 322.5 M^2 @ .70			225.75
Header Poly & Window Poly			540.00
			1,277.16
FOUNDATION - N/A			
CRAWL SPACE - Material:			
2 rolls - 6 M x 1500 poly	3	31.39	94.17
TAX			4.71
- Labor:			
Poly - 230.2 M^2 @ .70			161.14
Repairs After Urades			100.00
			360.02
RETRO-FIT READY poly costs per M^2 -			
Ceiling (19.2) = $ 2.63			
Walls (38.4) = $ 2.77			
Foundation = N/A			
Crawl Space Floor (20.33) = $ 1.48			

DOORS & WINDOWS CONSTRUCTION: RETRO-FIT READY APARTMENT

	AMOUNT	PRICE	EXTENSION
DOORS - 1 s.c. wood door	1	182.00	182.00
jamb ext. (8 7/8)	1	35.00	35.00
Better weatherstrip	1	22.00	22.00
Storm door # 120	1	87.98	87.98
			326.98
TAX			16.35
			343.33
- Labor: hang storm door	1	12.00	12.00
			355.33
WINDOWS - 4 3/8 jamb extended to 8 7/8			
Assume: 6 units face north and 6 units face south.			
(a) north facing units (triple glazed)			
(b) south facing units (double glazed)			
Bedroom - 1 2W2 (a) 224.91 (b) 185.72			
Bath - 1 2924 (a) 126.46 (b) 107.83			
Liv.Rm.-1-30x30x30/60 (a) 385.14 (b) 298.68			
736.51 592.23			
TAX 36.83 29.61			
773.34 621.84			
Jamb Ext. - Material: 13.8 M 19 x 140 clear fir	28	95.65	22.00
TAX			1.10
			23.10
- Labor: 3 windows @ 10.00 ea. trim			30.00
3 windows @ 3.00 ea. paint			9.00
			62.10
Retro-Fit Ready Windows -			
Facing north - per unit cost - 773.34 + 62.10			835.44
Facing south - per unit cost - 621.84 + 62.10			683.94

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
40 - 38 x 89 - 10 M trusses cantilevered .600 ea. end	40	58.72	2,348.80
244 M^2 RSI 10.6 insulation	244	9.90	2,415.60
Cardboard Eave Beffles	80	.25	20.00
9 - 1200 x 2400 - 9 mm spr. (roof sht. & chimney box)	9	8.77	78.93
80 - 1200 x 2400 - 15 mm drywall	2560	268.39	687.08
TAX			156.74
- Labor:			
Frame - 244 M^2 @ 4.30			1,049.20
Drywall - 230.4 M^2 @ .86			198.14
Chimney Box - 6 @ 5.00			30.00
			6,984.49
WALLS - Material:			
268.8 - 38 x 89 spr. plates	588	268	157.58
374 - 38 x 89 spr. studs	1995	255	507.73
112 - 1200 x 2400 - 9 mm spr. sht.	112	8.77	982.24
268.8 - 38 x 64 spr. plates	134	274	36.72
374 - 38 x 89 spr. studs	1496	274	409.90
28 - 1200 x 2400 - 12 mm spr. plates	28	12.15	340.20
112 - 1200 x 2400 - 12 mm drywall	3584	207.05	742.07
26 M - 38 x 89 header blocking	57	268	15.28
67.2 M - X90 colorlox	220	900	198.00
TAX			169.49
- Labor:			
Frame - 488 M^2 @ 8.61			4,201.68
Insulation O.S. - 322.5 M^2 @ 1.94 (RSI 1.4)			625.65
- 322.5 M^2 @ 3.71 (RSI 3.5)			1,196.48
I.S. - 322.5 M^2 @ 2.53 (RSI 2.1)			815.93
Header Insulation O.S. - 20.5 M^2 @ 3.71 (RSI 3.5)			76.06
Header Insulation I.S. - 20.5 M^2 @ 2.53 (RSI 2.1)			51.87
Install Header Block			120.00
Install siding - 20.5 M^2 @ 3.77 M^2			77.29
Drywall extra trip			30.00
			10,754.17

MATERIAL & LABOR

CONSTRUCTION: SUPER ENERGY EFFICIENT APARTMENT

	AMOUNT	PRICE	EXTENSION
LOWER FLOOR JOIST AREA - Material:			
85 - 1200 x 2400 - 12 mm Tentest	85	6.02	511.70
576 M - 19 x 64 spr. nailers	472	403	190.22
TZX			25.10
- Labor:			
Frame - 244 M^2 @ 3.77			919.88
Insulation - RSI 5.6 - 244 M^2 @ 5.60			1,366.40
			3,023.30
BASEMENT - Material:			
134 M - 38 x 38 PT spr.	147	640	94.08
28 - 1200 x 2400 - 12 mm PT plywood	896	797	714.11
28 - 1200 x 2400 - 38 mm S.M.	896	440	394.24
TAX			60.12
- Labor:			
Frame			150.00
Insulation - 83.2 M^2 @ 1.10			91.52
			1,504.07
Crawl space floor - 76 - 1200 x 2400 - 38 mm S.M.	2432	440	1,070.08
- 7 yds. sand @ 20.00 ea.			140.00
TAX			60.50
- Labor:			
to spread sand & lay S.M. - 244 M^2 @ 1.20			292.80
			1,563.38
Assume: sand sumped at various locations and wheel-barrowed into place with protection for poly.			
Super Energy Efficient - Costs per M^2:			
Ceiling (19.2) = $ 30.31			
Walls (38.4) = $ 23.34			
Basement (3.36) = $ 37.30			
Floor Joist Area (20.33) = $ 12.39			
Crawl Space Floor (20.33) = $ 6.41			

VAPOR BARRIER CONSTRUCTION: SUPER ENERGY EFFICIENT APARTMENT

	AMOUNT	PRICE	EXTENSION
CEILING - Material:			
2 rolls - 6 M x 1500 poly	3	31.39	94.17
Caulking	6	5.45	37.70
TAX			6.34
- Labor: Poly - 244 M^2 @ .70			170.80
Caulking - 244 M^2 @ .70			170.80
Hole finding, Plumbing stacks, etc.			300.00
			779.81
WALLS - Material:			
3 rolls - 6 M x 1500 poly	4.5	31.39	141.26
Caulking	24	5.45	130.80
TAX			13.60
- Labor: Poly - 322.5 M^2 @ .70			225.75
Caulking - 322.5 @ .70			225.75
Header poly & Window poly			480.00
Hole finding			400.00
			1,617.16
Assume: living area to crawl space separation to be on main floor.			
: the tile underlay is put on top of poly before interior partitions go in.			
Main Floor Poly - 2 rolls - 6 M x 1500 poly	3	31.39	94.17
Caulking -	6	5.45	32.70
TAX			6.34
- Labor: Poly - 244 M^2 @ .70			170.80
Caulking - 244 M^2 @ .70			170.80
Repairs			300.00
			779.81
CRAWL SPACE poly to be the same as Retro-Fit Ready.			
SUPER E.E. poly costs per M^2 - Ceiling (19.2) = $3.38			
- Walls (38.4) = $3.51			
- Main Floor (20.33)=$3.20			
- Crawl Space(20.33)=$1.48			

TUMBLER RIDGE, BRITISH COLUMBIA

DOORS & WINDOWS

CONSTRUCTION: SUPER ENERGY EFFICIENT APARTMENT

	AMOUNT	PRICE	EXTENSION
DOORS - 1 s.c. wood door	1	182.00	182.00
jamb ext.		40.00	40.00
better weatherstrip		22.00	22.00
storm door # 120	1	87.98	87.98
			331.98
TAX			16.60
			348.58
- Labor: hang storm door			12.00
			360.58
WINDOWS - triple glazed - 773.34 per unit			
Jamb Ext. - 2 - 1200 x 2400 - 15 mm GIS fir	2		22.29
TAX			1.11
- Labor: trim - 3 @ 12.00			36.00
paint - 3 @ 5.00			15.00
			74.40
Windows cost per unit - $ 847.74			

APPENDIX II

SUMMARY OF INCREMENTAL CONSTRUCTION COSTS

(BUILDER COSTS ONLY, SASKATOON CONDITIONS)

	1975 STD.	MEAS. #1	MEAS. #2	MEAS. #3	R-R #1	R-R #2	SEE #1	SEE #2
CEILING	1,725	1,955	1,955	1,955	2,292	2,292	3,017	3,017
WALLS	1,668	1,907	1,920	1,907	2,168	2,529	3,069	3,069
FOUNDATION WALLS	0	492	492	828	935	935	1,903	1,903
SLAB	0	0	0	0	0	0	518	854
VAPOUR BARRIER	52	65	65	107	781	781	1,144	1,144
DOORS	382	424	424	424	710	710	721	721
WINDOWS	1,171	1,341	1,341	1,341	1,424	1,424	1,607	1,607
AIR MANAGEMENT	0	0	0	0	201	201	1,493	1,493
TOTAL	4,498	6,184	6,197	6,562	8,511	8,872	13,472	13,808
INCREMENTALS	BASE	1,186	1,199	1,564	3,513	3,874	8,474	8,810
INCREMENTALS		BASE	13	378	2,327	2,688	7,288	7,624
INCREMENTALS					BASE	361	4,961	5,297

FIG. II.1 BUILDER COSTS, 100 m^2 DETACHED UNIT

	1975 STD.	MEAS. #1	MEAS. #2	MEAS. #3	R-R #1	R-R #2	SEE #1	SEE #2
CEILING	1,393	1,579	1,579	1,579	1,851	1,851	2,437	2,437
WALLS	1,501	1,716	1,728	1,716	1,951	2,276	2,762	2,762
FOUNDATION WALLS	0	443	443	745	842	842	1,713	1,713
SLAB	0	0	0	0	0	0	410	676
VAPOUR BARRIER	44	56	56	94	667	667	988	988
DOORS	382	424	424	424	710	710	721	721
WINDOWS	944	1,081	1,081	1,081	1,148	1,148	1,296	1,296
AIR MANAGEMENT	0	0	0	0	201	201	1,493	1,493
TOTAL	4,264	5,299	5,311	5,639	7,370	7,695	11,820	12,086
INCREMENTALS	BASE	1,035	1,047	1,375	3,106	3,431	7,556	7,822
INCREMENTALS		BASE	12	340	2,071	2,396	6,521	6,787
INCREMENTALS					BASE	325	4,450	4,716

FIG. II.2 BUILDER COSTS, 80.6 m^2 DETACHED UNIT.

	1975 STD.	MEAS. #1	MEAS. #2	MEAS. #3	R-R #1	R-R #2	SEE #1	SEE #2
CEILING	1659	1880	1880	1880	2203	2203	2901	2901
WALLS	1234	1410	1420	1410	1603	1870	2269	2269
FOUNDATION WALLS	0	364	364	612	692	692	1407	1407
SLAB	0	0	0	0	0	0	498	821
VAPOUR BARRIER	44	57	57	85	658	658	944	944
DOORS	382	424	424	424	710	710	721	721
WINDOWS	1171	1341	1341	1341	1424	1424	1607	1607
AIR MANAGEMENT	0	0	0	0	201	201	1493	1493
TOTAL	4490	5476	5486	5752	7491	7758	11840	12163
INCREMENTALS	BASE	986	996	1262	3001	3268	7350	7673
INCREMENTALS		BASE	10	276	2015	2282	6364	6687
INCREMENTALS					BASE	267	4349	4672

FIG. II.3 BUILDER COSTS, 96 m^2 SEMI-DETACHED UNIT

	1975 STD.	MEAS. #1	MEAS. #2	MEAS. #3	R-R #1	R-R #2	SEE #1	SEE #2
CEILING	1306	1480	1480	1480	1735	1735	2285	2285
WALLS	1077	1231	1240	1231	1400	1633	1982	1982
FOUNDATION WALLS	0	318	318	534	604	604	1229	1229
SLAB	0	0	0	0	0	0	378	624
VAPOUR BARRIER	36	44	44	72	440	440	786	786
DOORS	382	424	424	424	710	710	721	721
WINDOWS	878	1006	1006	1006	1068	1068	1205	1205
AIR MANAGEMENT	0	0	0	0	201	201	1493	1493
TOTAL	3679	4503	4512	4747	6158	6391	10079	10325
INCREMENTALS	BASE	824	833	1068	2479	2712	6400	6646
INCREMENTALS		BASE	9	244	1655	1888	5576	5822
INCREMENTALS					BASE	233	3921	4167

FIG. II.4 BUILDER COSTS, 75 m^2 SEMI-DETACHED UNIT

	1975 STD.	MEAS. #1	MEAS. #2	MEAS. #3	R-R #1	R-R #2	SEE #1	SEE #2
CEILING	916	1041	1041		1171	1171	1538	1538
WALLS	1015	1173	1167		1329	1429	1661	1661
FOUNDATION WALLS	222	222	222		400	400	400	400
SLAB	0	0	0		0	0	289	477
VAPOUR BARRIER	31	40	40		519	519	630	630
DOORS	382	424	424		710	710	721	721
WINDOWS	878	1006	1006		1068	1068	1205	1205
AIR MANAGEMENT	0	0	0		201	201	1493	1493
TOTAL	3444	3906	3900		5398	5498	7937	8125
INCREMENTALS	BASE	462	456		1954	2054	4493	4681
INCREMENTALS		BASE	-6		1492	1592	4031	4219
INCREMENTALS					BASE	100	2539	2727

FIG. II.5 BUILDER COSTS, ROW HOUSING UNIT

	1975 STD.	MEAS. #1	MEAS. #2	MEAS. #3	R-R #1	R-R #2	SEE #1	SEE #2
CEILING	339	384	384		432	432	582	
WALLS	555	634	638		707	794	896	
FOUNDATION WALLS	32	32	32		51	51	256	
SLAB	0	0	0		0	0	252	
VAPOUR BARRIER	15	23	23		187	187	295	
DOORS	191	212	212		355	355	361	
WINDOWS	622	708	708		760	760	848	
AIR MANAGEMENT	0	0	0		201	201	900	
TOTAL	1754	1993	1997		2693	2780	4390	
INCREMENTALS	BASE	239	243		939	1026	2636	
INCREMENTALS		BASE	4		700	787	2397	
INCREMENTALS					BASE	87	1697	

FIG. II.6 BUILDER COSTS, APARTMENT UNIT

APPENDIX III

COMPUTED SPACE HEAT REQUIREMENTS

		RSI VALUES						
	AREA (m^2)	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
CEILING	100	3.5	5.6	5.6	5.6	7.1	7.1	10.6
WALLS	96	2.1	3.5	3.4	3.5	4.9	6.2	7.0
DOORS	3.2	0.95	0.95	0.95	0.95	0.95	0.95	1.8
WINDOWS, NON-SOLAR	5.5-3.0	5.5 / 0.3	3.0 / 0.3	3.0 / 0.3	3.0 / 0.3	3.0 / 0.57	3.0 / 0.57	3.0 / 0.57
WINDOWS, SOLAR	5.5-13.5	5.5 / 0.3	13.5 / 0.3	13.5 / 0.3	13.5 / 0.3	13.5 / 0.36	13.5 / 0.36	13.5 / 0.57
FOUNDATION ABOVE GRADE	24	0	1.4	1.4	1.4	1.32	1.32	3.9
TOP 600 mm BELOW GRADE	24	0	1.4	1.4	1.4	1.32	1.32	3.9
BOTTOM 1200 mm BELOW GRADE	48	0	0	0	1.4	1.32	1.32	3.9
SLAB	93	0	0	0	0	0	0	0.88
VENTILATION	VOL. 488	ACH. 0.6	0.5	0.5	0.5	0.3	0.3	0.18
HEAT LOSS (W/C)		410	317	318	283	228	224	138
SPACE HEAT/UNIT (GJ)		171	103	104	91	60	58	23

FIG. III.1 THERMAL PERFORMANCE, 100 m^2 DETACHED UNIT.

		RSI VALUES						
	AREA (m^2)	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
CEILING	80.6	3.5	5.6	5.6	5.6	7.1	7.1	10.6
WALLS	86.4	2.1	3.5	3.4	3.5	4.9	6.2	7.0
DOORS	3.2	0.95	0.95	0.95	0.95	0.95	0.95	1.8
WINDOWS, NON-SOLAR	4.5-2.0	4.5 / 0.3	2.0 / 0.3	2.0 / 0.3	2.0 / 0.3	2.0 / 0.57	2.0 / 0.57	2.0 / 0.57
WINDOWS, SOLAR	4.5-11.0	4.5 / 0.3	11.0 / 0.3	11.0 / 0.3	11.0 / 0.3	11.0 / 0.36	11.0 / 0.36	11.0 / 0.57
FOUNDATION ABOVE GRADE	21.6	0	1.4	1.4	1.4	1.32	1.32	3.9
TOP 600 mm BELOW GRADE	21.6	0	1.4	1.4	1.4	1.32	1.32	3.9
BOTTOM 12 mm BELOW GRADE	43.2	0	0	0	1.4	1.32	1.32	3.9
SLAB	73.6	0	0	0	0	0	0	0.88
VENTILATION	VOL. 393	ACH. 0.6	0.5	0.5	0.5	0.3	0.3	0.18
HEAT LOSS (W/C)		349	265	265	234	190	186	114
SPACE HEAT/UNIT (GJ)		144	85	85	74	49	47	18

FIG. III.2 THERMAL PERFORMANCE, 80.6 m^2 DETACHED UNIT.

		RSI VALUES						
	AREA (m^2)	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
CEILING	192	3.5	5.6			7.1	7.1	10.6
WALLS	142	2.1	3.5			4.9	6.2	7.0
DOORS	6.6	0.95	0.95			0.95	0.95	1.8
WINDOWS, NON-SOLAR	9.5-4.0	9.5 / 0.3	4.0 / 0.3			4.0 / 0.57	4.0 / 0.57	4.0 / 0.57
WINDOWS, SOLAR	9.5-23.0	9.5 / 0.3	23.0 / 0.3			23.0 / 0.36	23.0 / 0.36	23.0 / 0.57
FOUNDATION ABOVE GRADE	35.5	0	1.4			1.32	1.32	3.9
TOP 600 mm BELOW GRADE	35.5	0	1.4			1.32	1.32	3.9
BOTTOM 1200 mm BELOW GRADE	71	0	0			1.32	1.32	3.9
SLAB	100	0	0			0	0	0.88
VENTILATION	VOL. 936	ACH. 0.6	0.5			0.3	0.3	0.18
HEAT LOSS (W/C)		694	545			397	390	242
SPACE HEAT/UNIT (GJ)		146	91			53	52	22

FIG. III.3 THERMAL PERFORMANCE, 2 x 96 m^2 SEMI-DETACHED.

		RSI VALUES						
	AREA (m^2)	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
CEILING	151.2	3.5	5.6			7.1	7.1	10.6
WALLS	124	2.1	3.5			4.9	6.2	7.0
DOORS	6.6	0.95	0.95			0.95	0.95	1.8
WINDOWS, NON-SOLAR	7.5-4.0	7.5 / 0.3	4.0 / 0.3			4.0 / 0.57	4.0 / 0.57	4.0 / 0.57
WINDOWS, SOLAR	7.5-18.0	7.5 / 0.3	18.0 / 0.3			18.0 / 0.36	18.0 / 0.36	18.0 / 0.57
FOUNDATION ABOVE GRADE	31	0	1.4			1.32	1.32	3.9
TOP 600 mm BELOW GRADE	31	0	1.4			1.32	1.32	3.9
BOTTOM 1200 mm BELOW GRADE	62	0	0			1.32	1.32	3.9
SLAB	67.9	0	0			0	0	0.88
VENTILATION	VOL. 737	ACH. 0.6	0.5			0.3	0.3	0.18
HEAT LOSS (W/C)		531	405			282	277	169
SPACE HEAT/UNIT (GJ)		110	64			35	33	11

FIG. III.4 THERMAL PERFORMANCE, 2 x 75.6 m^2 SEMI-DETACHED.

		RSI VALUES						
	AREA (m^2)	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
CEILING	162	3.5	5.6			7.1	7.1	10.6
WALLS	109.7	2.1	3.5			4.9	6.2	7.0
DOORS	9.6	0.95	0.95			0.95	0.95	1.8
WINDOWS, NON-SOLAR	9.5-4.0	9.5 / 0.3	4.0 / 0.3			4.0 / 0.57	4.0 / 0.57	4.0 / 0.57
WINDOWS, SOLAR	9.5-23.0	9.5 / 0.3	23.0 / 0.3			23.0 / 0.36	23.0 / 0.36	23.0 / 0.57
FOUNDATION ABOVE GRADE	55	2.1	3.5			4.9	4.9	7.0
TOP 600 mm BELOW GRADE	27.5	2.1	2.1			4.9	4.9	4.9
BOTTOM 1200 mm BELOW GRADE	27.5	2.1	2.1			4.9	4.9	4.9
SLAB	160	0	0			0	0	0.88
VENTILATION	VOL. 790	ACH. 0.6	0.5			0.3	0.3	0.18
HEAT LOSS (W/C)		457	412			309	305	206
SPACE HEAT/UNIT (GJ)		53	36			19	18	6

FIG. III.5 THERMAL PERFORMANCE, 3 x 54 m^2 ROW UNITS.

		RSI VALUES						
	AREA (m^2)	1975 STD.	MEAS #1	MEAS #2	MEAS #3	R-R #1	R-R #2	SEE #1
CEILING	230.4	3.5	5.6			7.1	7.1	10.6
WALLS	327.7	2.1	3.5			4.9	6.2	7.0
DOORS	19.2	0.95	0.95			0.95	0.95	1.8
WINDOWS, NON-SOLAR	32	0.29	0.29			0.56	0.56	0.56
WINDOWS, SOLAR	32	0.29	0.29			0.37	0.37	0.56
FOUNDATION ABOVE GRADE	41	1.32	1.32			1.32	1.32	
FLOOR	230.4							4.5
CRAWL SPACE FLOOR	230.4	1.76	1.76	ASSUMED GROUND EFFECT		1.76	1.76	
VENTILATION	VOL. 1123	ACH. 0.6	0.5			0.3	0.3	0.18
HEAT LOSS (W/C)		744	638			463	453	259
SPACE HEAT/UNIT (GJ)		24	17			9.5	9.0	2.3

FIG. III.6 THERMAL PERFORMANCE, 12 x 38.4 m^2 APARTMENT UNITS

	AREA (m^2)	1975 STD.	UPGRADED					
CEILING	91	3.5	3.5					
WALLS	112	2.1	3.5					
DOORS	3.2	0.95	0.95					
WINDOWS, NON-SOLAR	5.0	0.29	0.37					
WINDOWS, SOLAR	4.2	0.29	0.37					
FOUNDATION ABOVE GRADE	31	0	1.4					
TOP 600 mm BELOW GRADE	31	0	1.4					
BOTTOM 1200 mm BELOW GRADE	62	0	0					
SLAB	91	0	0					
VENTILATION	VOL. 443	ACH. 0.8	0.3					
HEAT LOSS (W/C)		470	281					
SPACE HEAT/UNIT (GJ)		225	113					

FIG. III.7 THERMAL PERFORMANCE, 91 m^2 PRE-BUILD UNIT.

POOR

QUALITY

ORIGINAL